# Lerwick North Harbour
# Marine Mammal Risk Assessment

## December 2025

# CONTROL SHEET

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# EXECUTIVE SUMMARY

EnviroCentre Limited was commissioned by Arch Henderson to undertake a Marine Mammal Risk Assessment (MMRA) to inform a European Protected Species (EPS) licence for pretreatment drilling and blasting in relation to Lerwick dredging works. The proposed capital dredging works are driven by an urgent requirement to improve navigational safety through the harbour due to ever increasing vessel size and number being experienced in the port.

The proposed activity includes pretreatment drilling and blasting of harder rock strata that will be carried out before the dredging operations are initiated, plus dredging of some additional areas.

A review of available resources assessing underwater noise impacts of blasting and findings from similar projects was used to inform and assess likely Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) and general disturbance ranges for marine mammals as a result of blasting, dredging and drilling works required for this project. Blasting PTS ranges are considered to be within 1000m for a MIC of <30kg for all relevant cetacean hearing ranges, dredging PTS ranges for all relevant cetaceans are up to 82m and TTS are up to 350m (and up to 10,000m for harbour porpoise, although these species are considered highly adaptable with the ability to forage over large areas thus not anticipated to cause significant consequences of detrimental effects). Mitigation via Marine Mammal Observer and Passive Acoustic Monitoring (PAMs) (potential use of Acoustic Deterrent Devices (ADD), where necessary) and implementing an adaptive management trial drilling and blasting programme ahead of works with MMO monitoring zones at 500m and 1000m, will be implemented to reduce risks.

General disturbance to marine mammals may occur as a result of works. It is expected that marine mammals would be likely to exhibit a behavioural change due to the noise and physiological stress may also occur. This could impact marine mammals' energy and fitness levels through disturbing foraging or causing avoidance of feeding areas for periods of time. A 3.6km radius buffer for disturbance has been applied, which is identified as an appropriate buffer from Subacoustech calculations, in conjunction with the latest SCANS IV density data for marine mammals, to quantify the number of individuals that may be disturbed as a result of dredging, drilling and blasting works. The quantitative data show that a maximum of 16 harbour porpoises, 2 Risso's dolphin, 1 minke whale and 8 killer whales could be disturbed from noise related activities. These numbers are considered a 'worst case' scenario due to the most sensitive marine mammal (harbour porpoise) being used to determine the buffer distance (3.6km). Therefore, the actual numbers would likely be lower and, when compared to the abundance estimates for Shetland, are considered very low. Thus, the potential for disturbance is considered to be limited.

The increase in the number of vessels travelling through to Lerwick North Harbour during construction would increase the risk of collision with marine mammals, potentially resulting in death or injury to individuals, however Lerwick North Harbour is already part of an established port, and due to the high number of vessels utilising the area already, the likelihood is reduced.

Due to protocols, controls and mitigation outlined in section 5 required to be implemented during works, it is considered unlikely that marine mammals will be negatively impacted at a population level from works associated with the Lerwick North Harbour.

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# 1 INTRODUCTION

## 1.1 Terms of Reference

EnviroCentre Limited was commissioned by Arch Henderson to undertake a Marine Mammal Risk Assessment (MMRA) to inform a European Protected Species (EPS) licence for pretreatment drilling and blasting in relation to Lerwick North Harbour dredging works. The proposed capital dredging works are driven by an urgent requirement to improve navigational safety through the harbour due to ever increasing vessel size and number being experienced in the port.

## 1.2 Scope of Report

This study aims to establish which species are likely to be present and could be impacted by the proposed works to inform the requirements for a European Protected Species (EPS) licence from Marine Scotland. The objectives were as follows:

- Collate existing data in relation to designated sites, species records, distribution, population counts, habitat use and any other relevant information, to establish which species are likely to be present within the development site and the wider zone of influence of the development.
- Identify potential impacts to marine mammals which could occur as a result of the works.
- Detail appropriate mitigation actions to avoid or reduce potential impacts.

## 1.3 Background

A dredging & sea deposit licence is in place for capital dredging at Lerwick North Harbour (Ref MS-00011195) – the permitted volume is 602,000 wet tonnes.

Phase 1 of the dredging was carried out from July – September 2025 to remove all soft material using a trailer suction hopper dredger (TSHD) and backhoe dredging (BHD). Approximately 140,000m$^3$ of materials has been removed.

Since the original dredging campaign was planned, the appointed dredging contractor has put forward a method to over-dredge to ensure that the depth required for safe navigation is achieved. The dredge area is unchanged.

The volume remaining to be dredged under Phase 2 is approximately 209,489m$^3$ of rock. This updated MMRA supports a request to vary the existing marine licence to include drilling and blasting to remove the remaining rock.

## 1.4 Report Usage

The information and recommendations contained within this report have been prepared in the specific context stated above and should not be utilised in any other context without prior written permission from EnviroCentre Limited.

If this report is to be submitted for regulatory approval more than 12 months following the report date, it is recommended that it is referred to EnviroCentre Limited for review to ensure that any relevant changes in data, best practice, guidance or legislation in the intervening period are integrated into an updated version of the report.

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## 1.5 Project Overview

Since the original dredging campaign was planned, the appointed dredging contractor has put forward a method to over-dredge to ensure that the depth required for safe navigation is achieved and additional areas at Homsgarth, Scattland and Greenhead to be dredged. The volume remaining to be dredged under Phase 2 is approximately 209,489m$^3$ of rock.

Revisions include the below and are shown in Appendix A:

1. Minor dredging additions at Holmsgarth, Scattland and Greenhead channel with some omissions.
2. Pre-treatment of hard rock strata using blasting over a duration of 5 weeks, including contingency time for any delays due to weather or marine mammal presence and drilling may be undertaken 24 hours a day, seven days a week.
3. Larger vessels are proposed to reduce return trips to the designated dredge disposal site from 24 / day previously assessed down to 5 per day.
4. Contingency over dredge volume allowance based on contractor's methods that may not all be required (current contingency allowance of 152,000m$^3$ has been calculated).
5. While the dredging duration remains unchanged, dredging may be undertaken partly in winter.

Dredged materials will be disposed of at the nearest existing licensed sea disposal site (FI080) for LPA, which is approximately 350m offshore north of Bressay (centre point approximately OSGR HU 48277 45111), hereafter referred to as the 'disposal site'. The disposal site is located in naturally deep water with ease of access, has a large capacity with a footprint of 145,000m$^2$ in 30m of water and is anticipated to be active for the foreseeable future.

It should be noted that the dredging works at Lerwick North Harbour will be undertaken under the same contract as the dredging works at Dales Voe. The current intention is to undertake the dredges consecutively with North Harbour completed first and then Dales Voe, over a period of 11 weeks.

The proposed works area and disposal site are located in Appendix A. The proposed work area covers approximately 46.06 ha/ 0.4606 km$^2$.

### 1.5.1 Construction Methodology

**Capital Dredging**

The contractor completed Phase 2A Backhoe dredging works in Lerwick on 8th October 2025, with the pre-survey paid volume above design = 354,455m$^3$, interim survey volume above design = 54,706m$^3$ and total Lerwick dredge contract complete to date= **84.56%.**

The current dredging campaign now awaiting Marine Directorate / NatureScot assessment of the required final drill and blast (D&B) dredging campaign to complete dredging down to design levels using agreed methods and mitigation.

On completion of the drilling and blasting, dredging will be undertaken using backhoe methods to remove blasted material from the seabed. The dredged material will be transferred to a split hopper barge. This material will then be deposited at the disposal site.

A Dredging Best Practicable Environmental Option Report (BPEO)[1] has been produced for the proposed development, informed by sediment sampling at both the North Harbour dredge site and the disposal site. Samples from North Harbour were noted to be largely either sand (25% to 79%) or silt (6% to 42%) sized fractions. Gravel sized material ranged from 1% to 69% in samples submitted for analysis. The BPEO included with the original application confirmed volumes in m$^3$, and the table below shows these together with additional volumes from the proposed revised dredging, together with a further contingency allowance for any over dredge due to specific dredging techniques:

**Table 1.1: Summary of Dredge Volumes and Depths**

| Dredge Area | Dredge Volume (m$^3$) | Target Dredge Depth (m below Chart Datum) |
|---|---|---|
| Holmsgarth -7m CD | 11,450 | -7.0 |
| Holmsgarth -10m CD | 225,050 | -10.0 |
| Holmsgarth -10.5m CD | | -10.5 |
| Mair's Pier South | 200 | -8.0 |
| Hedogan Tuning Circle | 34,100 | -9.0 |
| North Ness Channel | 30,350 | -10.0 |
| **Lerwick Harbour Total Volume** | **301,150** | |
| | | |
| **Additional Material from drawing 232029-MD-20 (June 2025)** | | |
| Holmsgarth Additional (Area A) | 39,100 | 10 |
| Holmsgarth Berth 5 (Area E) | 733 | -9 |
| Scattland Channel (Area G) | 6,426 | -9 |
| Greenhead Channel (Area H) | 11,230 | -9 |
| Over Dredge (est. 300mm ave.) | 152,000 | |
| **Lerwick Harbour Total Volume (Revised)** | **510,639** | |

Due to the relatively coarse nature of the dredge material, and the weak tidal currents within the vicinity of the proposed dredge pockets, plumes generated as a result of the dredging works will be very localised and short term in duration. Due to the low current speeds, any sands and gravels lost to the water column during dredging will fall out of suspension quickly, within the dredge footprint. Similarly, it is expected that the majority of the deposited material will fall out of suspension quickly at the disposal site with limited lateral spread. However, the presence of silt will result in this material

[1] EnviroCentre (2024). Dales Voe and Lerwick Harbour North Best Practicable Environmental Option. Document number 14356.

having a slightly longer suspension potential. The disposal site is a sacrificial disposal ground with a large footprint, and as such there is considered to be an allowance for some lateral dispersal of materials within the area of disposal over time due to sites typically being dispersive, rather than retentive.

The BPEO report concluded that several of the North Harbour samples contained levels of contaminants above Marine Directorate Revised Action Level (RAL) 1, but there were no exceedances of RAL2. Despite this, assessment of the key receptors identified from the Water Framework Directive assessment for estuarine and coastal waters concluded there is a low risk of the sediments impacting upon the overall ecological or chemical status classifications. The levels of contaminants encountered are typically within levels accepted for sea deposit of dredged material. Additionally, the contaminant levels recorded in the sediment are not considered likely to have a significant adverse impact once placed within the disposal site.

It is noted that the Lerwick disposal grounds have been utilised for historic dredge spoil disposal, and water quality classification for chemical status of the waterbody, which accommodates the disposal grounds was classified by SEPA as “good” in 2022[2]. On this basis, the associated risk with degradation of water quality directly associated with the proposed disposal is considered to be low, i.e. unlikely to cause a change in the status of the waterbodies in question at both the dredge and disposal sites.

**Drilling and Blasting**

Rock that could not be directly dredged during Phase 1 using a backhoe or trailer dredger, either because of rock strength or low fracture rate, will require pre-treatment using drill and blast methodologies. The drilling and charging will continue on a 24 hours a day, 7 days a week basis.

Drilling and blasting will occur from a specialist drill platform, ‘Rockmate’, equipped with two marine drill tower units. The ‘Rockmate’ is 41m x 18m and utilises four spud legs (avoiding the requirement for anchor spread).

*Drilling*

To determine the starting position of the ‘Rockmate’, a drill/-blast location will be determined in a less sensitive area to gather information on vibration and underwater noise impact. Drilling will start at the minimum rock layer depth, meaning the explosive placed into the hole can be reduced, so the Maximum Instantaneous Charge (MIC) will also be small.

The drill pattern will vary between the areas based on design thickness, rock strength and locality to structures. The space between drill points will vary from 2.0m-5.0m, covering approximately 4m$^2$ to 20m$^2$ for each drill point. The drill pattern will be adjusted as required. Drilling will extend up to 2m below design to ensure the later dredging can fully remove the rock to the required design level and to reduce the number of pinnacles created during the blasting operation. Drill holes can vary in diameter from 85mm to 165mm. To ensure that the blasting extends over the full dredge area, it will be necessary to drill up to 1-2m beyond the planned extents of the dredge area.

*Blasting*

Offshore Kemiitti Explosives, a liquid explosive, with packaged boosters and detonators, will be used for the works. These explosives are specifically tailored to be used in underwater rock blasting. In addition, provision for EXEM 100 50mm diameter packaged emulsion provided by Explosives and

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[2] https://map.environment.gov.scot/sewebmap/

Pyrotechnic Consultants (EPC) for required controlled works to manage MIC weights and thus controlling vibration as required.

Trial blasting is required to ascertain the site parameters for vibration predictions. Initial trial blasting will be carried out as part of the production, but with charged levels reduced to ensure vibration levels at nearby structures stay below the normal operational safe limits. Several trail blasts over the first days will be used to take these trial measurements.

A warning signal (both aural and visual) will be emitted several minutes before the blast, and the area checked visually for the presence of swimmers, divers, vessels, mammals, etc. in good time.

A typical example of a blast warning procedure is:

- The local VTS and other specified parties will be informed 60 minutes prior planned blasting.
- Ten minutes before blasting: - Relevant parties will be informed by radio and/or phone.
    - A blasting control vessel equipped with red flag will depart the 'Rockmate' to patrol the designated safety area. An additional fast craft vessel will be available to encourage species out of the Marine Mammal Observer (MMO) area, if required. Acoustic Deterrent Devices (ADDs) will also be available on site but will only be used if persistent issues arise with species converging into or not leaving MMO area just prior to a blast.
    - VTS will be contacted to obtain all clear to blast (vessel traffic, divers etc.)
- The supervisor onboard will make a visual check of the area and obtain confirmation from the blasting control vessel that everything is correct.
- Upon receipt of clearance short sound signals will be given, and the blast will be initiated after the last signal.
- After successful blasting one long sound signal will be given, and the relevant parties will be informed on the radio that blasting is completed.

The use of bubble curtains have currently been discounted as it would be extremely challenging to deploy them effectively in open water and the presence of the existing heavy vessel traffic, for individual blasts at different locations. In a NatureScot report (2019)[3] which completed a review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters concluded that 'big bubble curtains' are effective for prolonged piling of large wind turbines, however, the evidence is mixed for blasting[4]. In addition, the report also acknowledges the significant logistical challenges and high costs of deploying them for individual blast locations. Furthermore, during the works at the Aberdeen South Harbour project, where double bubble curtains were implemented as mitigation, only 12 blasts were carried out in 96 days, for various reasons, but primarily due to the presence of seals in the mitigation zone for hours on end, and/ or adverse weather conditions preventing bubble curtain from being operated effectively. As a result, blasting was abandoned, and instead, backhoe dredging was undertaken.

The quantity of explosives in each hole will be dependent on the layer of rock and findings from trial blasting, which will start at MIC 20kg and work up in small increments (2kg or 5kg) whilst monitoring noise levels at 500m and 1000m (see Section 1.4.2 for further details). When noise levels reach near the PTS range at 1000m of the hearing frequencies of any marine mammals considered to be within waters associated with the site location (all relevant pinnipeds and cetaceans), then this will identify the maximum MIC for the project. It is also estimated that 9-90 holes will be drilled for each field.

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[3] Verfuss, U.K., Sinclair, R.R. & Sparling, C.E. 2019. A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Research Report No. 1070.
[4] This report refers to blasting from detonating UXOs, rather than blasting in the same respect as this project, so although some differences, the theory is considered relevant.

Charges will go off at the beginning and end of each day (during daylight). Blasting is expected to occur over a duration of 5 weeks at Lerwick North Harbour, weather dependent, and may be undertaken partly in winter.

As part of an overall mitigation of blast noise impact intensity, the contractor is proposing to use 25 millisecond blast delays between each charged hole to help minimise the MIC / Qmax value for each overall blast. A sample blast design calculation is detailed in Figure 1-1. It shows a drill pattern with a typical overall total charge weight of 980Kg over 30 holes, but with blast delays resulting in an MIC/ Qmax value of 70Kg. This individual blast hole charge delay method was previously used at Lerwick Harbour dredge campaign in 2008 and during the Holmsgarth Pier Development in 2018.

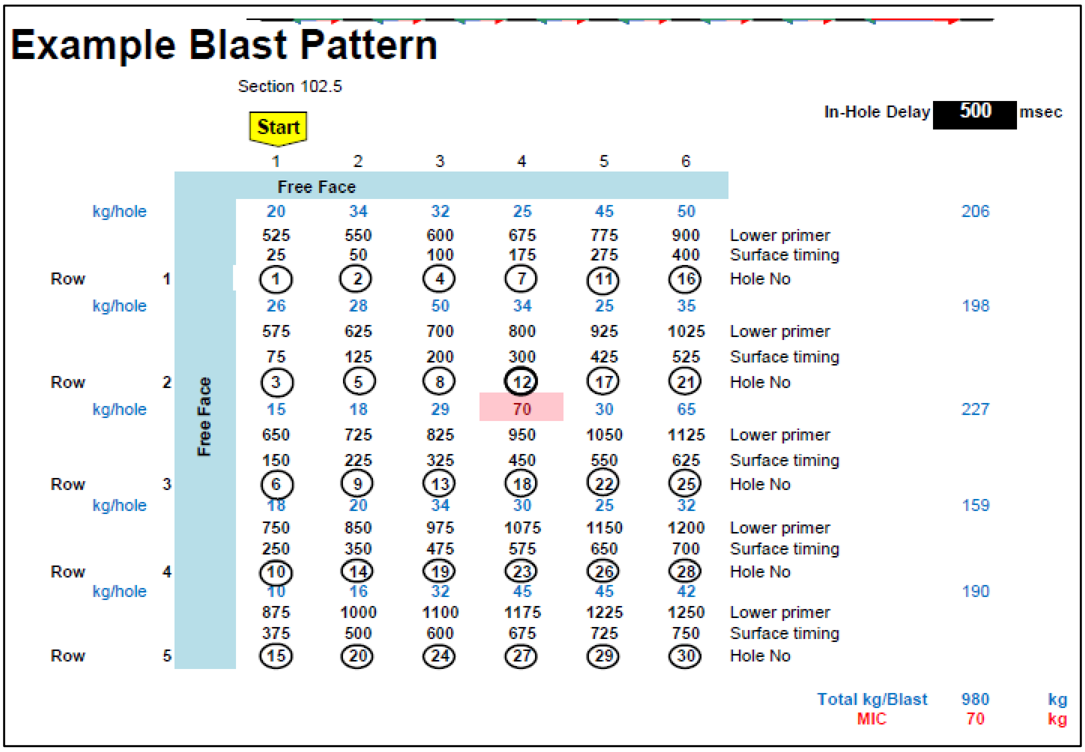


**Figure 1-1: Example blast pattern previously used at Lerwick Harbour dredge campaign in 2008 and during Holmsgarth Pier Development in 2018 obtained from the drilling and blasting method statement provided by the contractors**

### 1.5.2 Trial Blasting Mitigation

**Underwater noise monitoring**

In order to record impulsive noise in the field and assess relative to the above MMO mitigation zones then the following method is proposed to be undertaken by a specialist underwater acoustic noise contractor during a programme of trial blasts leading onto the main drilling and blasting campaign in order to have confidence that suitable and practical MMO distance is used.

In order to monitor underwater noise levels during blasting, measurements of blast noise will be recorded simultaneously at locations of 500m and 1000m from the trial blast centre in a direction north of blast. The trial test blast locations will be determined in a less sensitive area to gather information on vibration and underwater noise impact. The proposed trial blast method is to restrict initial MIC to 20Kg with incremental trial increases (2kg or 5kg) up to an agreed maximum MIC that maintains underwater noise impact thresholds below disturbance levels for marine mammals at the agreed MMO distance. The objective is to ensure that all recording stations lay along a direct line-of sight transect commencing at the blast field.

Two boats will be used during the drilling and blasting trials with hydrophones capable of detecting marine mammals. The provided vessels must go dead ship (engines and depth sounders switched off) and drift for a short duration for each trial blast to enable high quality data capture from the blast events.

If at any time during the D&B dredging works, there are issues with marine mammals converging inside the agreed MMO distance, then an ADD will be available on site and deployed on the above boats to encourage marine mammals to leave the area ahead of the blast. The ADD is essentially a transducer on the end of a 50m cable connected to a topside unit with only a single switch to turn the device on or off. A back-up spare device will be deployed on each boat.

Blasting will not take place when the weather and sea state affect the efficiency of the MMO and mitigation measures.

Prior to each blasting schedule, a specialist noise survey team will liaise with the Boskalis Westminster Ltd blasting engineers to ensure that two survey vessels are on the 500m and 1000m lines in good time. Noise data, that is collected at each recording station over durations ranging from a few minutes to one hour or more, will be recorded to provide general background noise, which can be calibrated and used in the data acquisition system to provide a standardised noise level against which all subsequent measurements would be compared, and the blast noise itself.

In addition to the noise data, the specialist noise survey team will also collate log sheets indicating which blast field was being drilled; the numbers of boreholes prepared, the numbers of charges that were successfully detonated, the state of weather and tide, and any other sources of noise that were present in the area from time to time. All data will then be made available for subsequent data processing and analysis.

**Analysis and reporting**

The noise data will be supplied as voltage-time series in one or more .WAV files. Subsequently, a calibration adjustment factor related to the ratio of the output signal amplitude to the input signal amplitude will be applied to the blast wave data.

Two boats will be used during the drilling and blasting trials with hydrophones (Passive Acoustic Monitor (PAM)) capable of detecting marine mammals at 500m and 1000m.

The blast data will then be converted into a pressure-time series after taking into account the hydrophone frequency sensitivity; the terminal unit gain settings; and calibration factor. The maximum amplitude of each blast event is then transcribed to give the peak blast level at each station distance. The rms value is then ascertained over each time duration. From the positional data contained within both Boskalis Westminster Field Contractor’s Log and the special monitoring contractors log, the distance between the blast site and each recording station is determined.

Summaries of the peak and rms noise levels at each station are then established.

Results will then be shared with MD-LOT and NatureScot with recommendations on final practical MMO distances and impulsive noise limits for marine mammals to avoid temporary and permanent noise-induced threshold shifts; TTS and PTS. Additional mitigation actions will be outlined if PTS are outside the mitigation zones.

**Marine mammal detection**

The project will provide visual MMOs and the requirement for marine mammal vocalisation detection would also be required via the inclusion of a PAM during trial works and project works.

To comply with Joint Nature Conservation Committee (JNCC) guidelines, the PAM system will be operated by an experienced PAM operator. The PAM operator will be responsible for deploying the vertical PAM system and documenting all PAM actions, including deployment times and detection records.

## 1.6 Vessel Movements Associated with Works

### Current Vessel Movement

Given that Lerwick Harbour is already part of an established port, the baseline level of vessel movements is relatively high in and around the proposed works. The annual average vessel density for all vessel types, within the vicinity of the site, shows vessel densities ranging from 0.5->100, as shown within **Error! Reference source not found.**, with the image taken from the National Marine Plan Interactive (NMPi) map[5].

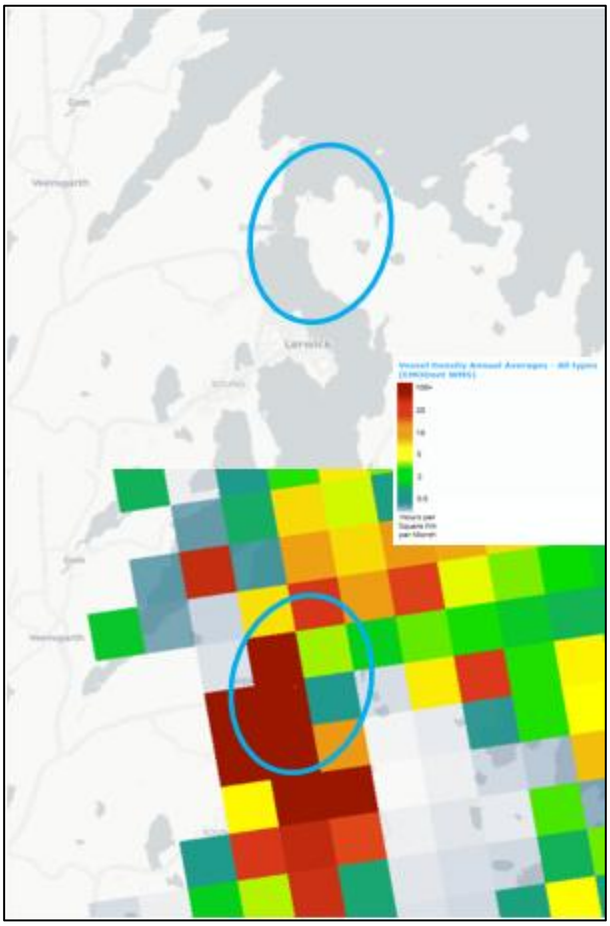

**Figure 1-2: Annual average vessel density based on vessel Automatic Identification System (AIS) data. The basemap showing the location of Lerwick North Harbour is shown above, with the vessel density below, and approximate location of works indicated by blue circle.**

[5] Marine Scotland (2024). Vessel Density Annual Averages - All types (EMODnet WMS) NMPi Map. Available at: https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?layers=1972 [Accessed June 2024]

**During Works**

*Dredging*

The dredging works will include associated vessel movements with the dredging itself and then barges moving between the dredge site and the disposal site.

Movements associated with the drill and blast campaign are approximately a maximum four to five barges per 24 hours throughout the overall final D&B / dredging period. Therefore, total vessel movements in Lerwick to complete the dredging is approximately 55 to 70 total barge transits over 5 weeks, depending on final over dredge quantities.

The vessel route is still expected to run from the dredge location in North Harbour, through the north mouth of Lerwick Harbour, and heading east towards the disposal site off the north coast of Bressay. The vessel route is approximately 3.5km long.

*Drilling and Blasting*

The explosives will be delivered in 75 tonne loads by coaster to Lerwick, taking station at one of the three Dangerous Goods anchorages specified by Lerwick Port Authority. Two vessel movements are proposed to facilitate this.

Once the area requiring pre-treatment has been established, the ‘Rockmate’ will be towed to the location and positioned using the onboard RTK/ DGPS positioning equipment.

# 2 METHODS

## 2.1 Baseline

In order to anticipate the potential marine mammal ecological sensitivities at the site and assess potential impacts of underwater noise, a desk study was conducted. The following sources were checked:

- Marine Directorate National Marine Plan interactive (NMPi) for
  - Location of marine designated sites;
  - Distribution of Priority Marine Features
- NatureScot Sitelink for other designated sites which may be associated with local marine mammal populations[6].
- Marine Scotland (MS) Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters [78;]
- JNCC Report No 680: Updated abundance estimates for cetacean management units in UK waters[9];
- Sea Watch Foundation (SWF) website for recent sightings of marine mammals from the Shetland region[10];
- Scottish Marine Animal Stranding Scheme (SMASS) for records of strandings between 2001 and 2020[11];
- ORCA website for recent records[12]
- JNCC website for Marine Protected Areas[13]
- Subacoustech report for underwater noise generated by drill and blast operations to inform blasting and general disturbance for Lerwick Harbour & Dales Voe (December 2025)[14]
- Research by Todd, et al. conducted in Shetland on dredging[15]
- Aberdeen Harbour Expansion Project Environmental Statement (AHEPES) underwater noise modelling on dredging[16]

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[6] SiteLink - Map Search (Accessed 22/08/2025)
[7] Marine Scotland Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters, Scottish Marine and Freshwater Science, Vol 11 No 12, available at: https://data.marine.gov.scot/sites/default/files/Scottish%20Marine%20and%20Freshwater%20Science%20%28SMFS%29%20Vol%2011%20No%2012%20Regional%20baselines%20for%20marine%20mammal%20knowledge%20across%20the%20North%20Sea%20and%20Atlantic%20areas%20of%20Scottish%20waters.pdf (Accessed 22/08/2025)
[8] Regional baselines for marine mammal knowledge across the North Sea and Atlantic areas of Scottish waters: Appendix 3 - SCANS surveys Scottish Marine and Freshwater Science Vol 11 No 12, available at: https://data.marine.gov.scot/sites/default/files//Scottish%20Marine%20and%20Freshwater%20Science%20%28SMFS%29%20Vol%2011%20No%2012_%20Regional%20baselines%20for%20marine%20mammal%20knowledge%20across%20the%20North%20Sea%20and%20Atlantic%20areas%20of%20Scottish%20waters%20-%20Appendix%203%20SCANS%20surveys%20%281%29.pdf (Accessed 22/08/2025)
[9] IAMMWG. 2022. Updated abundance estimates for cetacean Management Units in UK waters. JNCC Report No. 680 (Revised March 2022), JNCC Peterborough, ISSN 0963-8091. Available at: https://data.jncc.gov.uk/data/3a401204-aa46-43c8-85b8-5ae42cdd7ff3/jncc-report-680-revised-202203.pdf (Accessed 22/08/2025)
[10] Sea Watch Foundation Recent Sightings Shetland available at: https://www.seawatchfoundation.org.uk/recentsightings/ (Accessed 22/08/2025)
[11] Species reported within a 10km (sea route) from 2001-2020 to Scottish Marine Animal Stranding Scheme (SMASS) available at: https://strandings.org/map/ (Accessed 22/08/2025)
[12] ORCA Whale and Dolphin Sightings interactive map, available at: https://orca.org.uk/whale-dolphin-sightings (Accessed 22/08/2025)
[13] https://www.nature.scot/professional-advice/protected-areas-and-species/protected-areas/marine-protected-areas-mpas| NatureScot (Accessed 22/08/2025)
[14] *Subascoustech report P438LR0102*
[15] Todd, V. L. G., Todd, I. B., Gardiner, J. C., Morrin, E. C. N., MacPherson, N. A., DiMarzio, N. A., and Thomsen, F. A review of impacts of marine dredging activities on marine mammals. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu187
[16] Microsoft Word - 01 Introduction to the Proposed Development FINAL.docx

- Underwater noise modelling undertaken for Hatston[17] in Orkney by Irwin Carr

## 2.2 Calculating Permanent and Temporary Threshold Shift

### 2.2.1 Underwater Noise Producing Activities

The way in which noise affects marine mammals is dependent on several factors, including the type of noise generated, the noise level, the species of marine mammal and the distance between the animal and the source of the noise. The National Oceanic and Atmospheric Administration (NOAA) describes how different groups of marine mammals hear and are affected by sounds, which can be found in the *'Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing'*[18]. The effects can be described as either a Permanent Threshold Shift (PTS), where an animal experiences irreversible damage to their hearing which can in turn affect their ability to forage and reproduce and in extreme circumstances result in death; or a Temporary Threshold Shift (TTS) which an animal can recover from, but may experience 'masking' which reduces its ability to communicate with other animals and locate prey, resulting in fatigue[19].

Cetaceans rely on their hearing for foraging, navigation and mating. The impact of noise on a population level is difficult to determine, however, the expected impact on an individual animal's hearing ability and potential damage that could be caused by noisy activities during works is assessed by modelling representative scenarios, taking into account environmental variables and the animal's hearing capabilities.

Although this application mainly only concerns the blasting and drilling elements to support the existing dredging campaign, an element of dredging would be required following drilling and blasting, therefore, all three construction methods are considered.

The hearing groups from the National Marine Fisheries Service (NMFS) 2024[20] guidance were used to inform the effects of underwater noise producing activities associated with the project (dredging, drilling and blasting). The NMFS guidance is compiled by collating available scientific literature to produce criteria for the onset of TTS and auditory injury (AUD INJ), which includes, but is not limited to, PTS. This document includes a protocol for the formation of marine mammal hearing groups, the derivation of marine mammal auditory weighting functions, and the estimation of AUD INJ onset criteria for impulsive (e.g., airguns, impact hammers, explosives) and non-impulsive (e.g., tactical sonar, vibratory hammers, drills) sound sources.

As no underwater noise modelling has been undertaken for the project, instead a review of existing research and projects with modelling considered to include similar parameters (charge weights, number of blasts, dredging methods, etc.) was undertaken to assess impacts in relation to noise associated with the works and PTS and TTS.

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[17] RP001 Rv3 2022248 (Hatston Pier UW Modelling)
[18] NOAA guidance available at: http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm (Accessed 22/08/2025)
[19] JNCC UK Marine Noise Registry: Information Document available at: https://data.jncc.gov.uk/data/177d89a6-0f84-4eef-aefb-9fe6d781e7cd/MNR-InfoDoc-V1.0-20160907.pdf (Accessed 22/08/2025)
[20] 2024 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0)

### 2.2.2 Acoustic Deterrent Devices (ADDs)

ADDs may be used to support works during drilling and blasting, where deemed appropriate. However, due to the nature of ADDs, this can have a negative effect on marine mammals and therefore a review of existing research in relation to the impacts on marine mammals as a result of the works associated with the development is to be undertaken.

## 2.3 Calculating General Disturbance

In order to try and obtain an indicative numerical value for the number of individual marine mammals that could be impacted, as a result of the noise related activities, a similar approach was undertaken to that adopted for the Marine Directorate and European Protected Species (EPS) licensing applications.

To calculate the number of individuals likely to be present within the behavioural impact ranges, the following process was used:

Step 1 – Obtaining at sea area of maximum buffer distances for disturbance

Subacoustech provided thresholds alongside the calculated result for a selection of charge weights (with embedded charge correction) for marine mammals.

Once an appropriate buffer distance is established, the 'at sea' area within which it covers is obtained (per $km^2$).

Step 2: Obtain marine mammal density

Where available, Scans IV[21] block density estimates have been used to calculate the maximum numbers of individuals likely to be present within the area. Where this number was less than one, the figure has been rounded up as it would not be possible to disturb less than one individual. For some species, the Scans IV density estimates are 0 individuals or are not available, however, records indicate they may be present. In this case, the number of individuals have been estimated based on the number of individuals reported within recent sightings from Shetland (in the past three years) on the Sea Watch Foundation, with the highest figure used on a precautionary basis.

Step 3: Individuals per $km^2$

The estimated number of individuals per $km^2$ is then calculated as the marine mammal density calculated in Step 2 multiplied by the area of the 'at sea' disturbance buffer distance.

Where the calculated number of individuals is not an exact number, the figure has been rounded up, as it would not be possible to cause disturbance to a fraction of an individual.

## 2.4 Effects of Increased Vessel Movements

As increased vessel movement has the potential to increase collisions with marine mammals, an assessment of the increase in vessels associated with the works has been undertaken, with a review of relevant resources to inform the assessment.

[21] https://www.tiho-hannover.de/fileadmin/57_79_terr_aqua_Wildtierforschung/79_Buesum/downloads/Berichte/20230928_SCANS-IV_Report_FINAL.pdf

### 2.4.1 Disclaimer

It should be noted that the baseline is limited by the reliability of third-party information and the geographical availability of biological and/or ecological records and data. The absence of species from biological records cannot be taken to represent actual absence. Species distribution patterns should be interpreted with caution as they may reflect survey/reporting efforts rather than actual distribution.

# 3 BASELINE

## 3.1 Marine Protected Areas

Marine Protected Areas (MPAs) in Scottish waters safeguard a diverse array of habitats, species, geological features, and underwater landforms.

The closest MPA to site is the Mousa to Boddam MPA, located approximately 19.5km to the south. This MPA encompasses sandeel grounds around the island of Mousa and off the coast at Boddam in south-east Shetland[22]. These sandeel populations are crucial to the local ecosystem, serving as a vital food source for numerous fish, seabirds, seals, whales, and dolphins.

The East Mainland Coast, Shetland Special Protection Area (SPA) boundary is also situated in the site. The area included within the SPA supports populations of European importance of the following Annex 1 species:

- Great northern diver *(Gavia immer)*
- Red-throated diver *(Gavia stellata)*
- Slavonian grebe *(Podiceps auritus).*

No designated sites related to marine mammals are present within or directly adjacent to the development area.

## 3.2 Marine Mammal Baseline Summary

All cetaceans present in Scottish waters are European Protected Species (EPS) and all the species highlighted below are as Priority Marine Features[23] (PMFs).

**Harbour Porpoise**
The harbour porpoise (*Phocoena phocoena*) is widely distributed and common throughout the Shetland region. Harbour porpoise are predominantly confined to shelf waters, although sightings have occurred in deep water. Although present throughout the year, most sightings associated with Shetland region occur during summer-autumn (June to October), with the peak number of records occurring in July-August.

Harbour porpoise eat a variety of fish, cephalopods and crustaceans, determined by local availability. Prey species including herring (*Clupea harengus)*, sprat (*Sprattus sprattus*), pouting (*Trisopterus luscus*), sandeel (*Ammodytes tobianus*), gobies (*Gobiidae*), cod (*Gadus morhua*), saithe (*Pollachius virens*) and whiting (*Merlangius merlangus*)[24].

No harbour porpoise sightings have been recorded within the proposed development site. However, eight sightings were reported between 2023 and 2025 in surrounding waters. The closest involved three individuals observed at Burra, around 12km southwest of the site. A group of five was seen at Quendale Bay, approximately 32km southwest. A separate sighting of four porpoises occurred about 25km to the south, while three were recorded roughly 38 km south of the site. Two individuals were

[22] NatureScot, Mousa to Boddam MPA available at https://www.scotlink.org/link-campaigns/save-scottish-seas/scottish-marine-protected-area-network/mousa-to-boddam-mpa-proposal/ (Accessed 22/08/2025)
[23] Priority Marine Features in Scotland's seas - Habitats | NatureScot (Accessed 22/08/2025)
[24] SWF, harbour Porpoise fact sheet (2020), available at: https://www.seawatchfoundation.org.uk/wp-content/uploads/2020/07/Harbour-Porpoise.pdf (Accessed 22/08/2025)

sighted 16km south. Single porpoises were noted 16km to the west and 19km to the south of the site, respectively. The most distant record was of a lone individual observed around 43km to the south.

A total of 23 sightings of harbour porpoise comprising 16 sources have been submitted to ORCA between 2017-2021, predominantly to the southeast of the development site.

In the 2023 report on estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys, the most recent harbour porpoise abundance estimates for the assessment unit covering Shetland (North Sea (NS)) based on SCANS-IV data are 338,918 individuals (95% confidence interval: 243,063 – 476,203). Figure 2-1 shows the predicted density surface for harbour porpoise in 2022 using SCANS-IV survey data. The predicted density around the development site is within the range of 0.40–0.77 animals per km², consistent with values reported for the broader North Sea assessment unit.

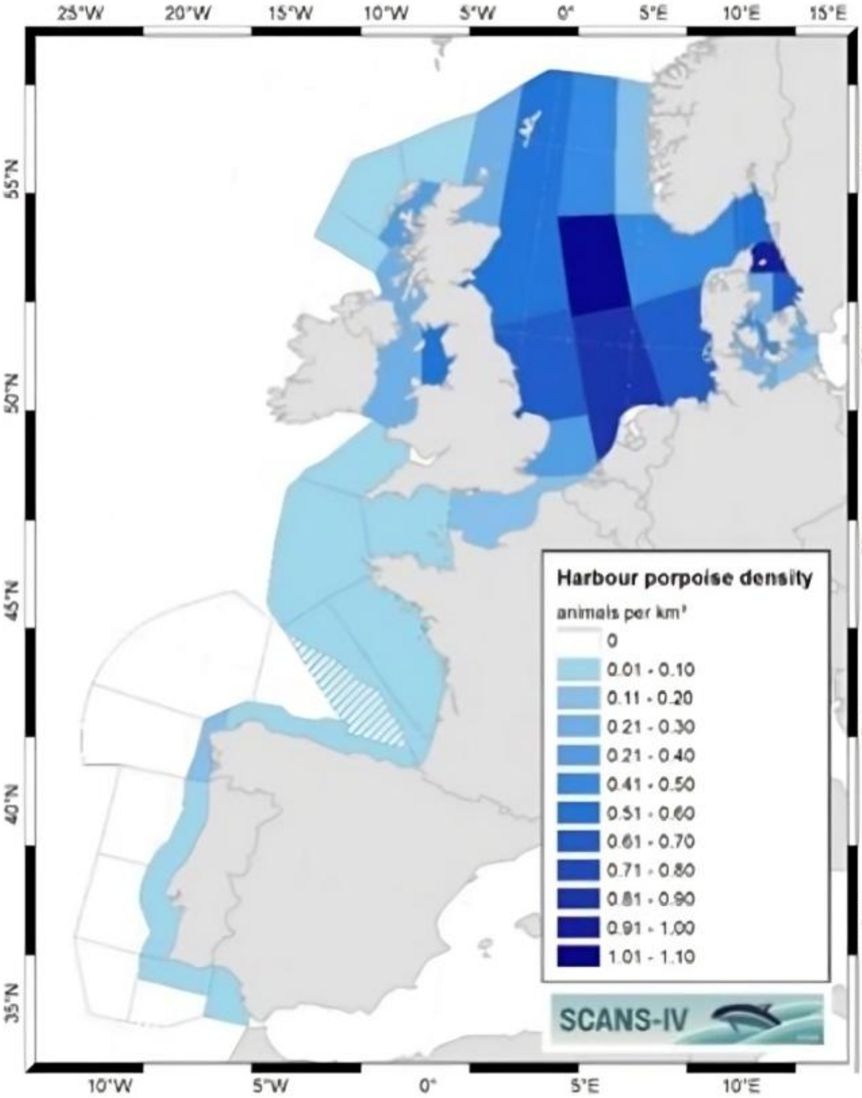


**Figure 3-1: Predicted density surface for harbour porpoise in 2022 using SCANS IV survey data.**

From the information gathered (number and locations of records), it is considered that harbour porpoise is present occasionally within the vicinity of the site and may be impacted by the works.

**Risso's Dolphin**

Risso's dolphins *(Grampus griseus)* in the north-east Atlantic are primarily found from the tropics to the Shetland Isles, Scotland. Major populations are concentrated in the Hebrides, with regular sightings in small numbers in Shetland, Orkney, and NE Scotland, as well as in the Irish Sea, particularly off the coasts of Co. Wexford, west of Pembrokeshire, around NW Wales, and the Isle of Man. In recent years, they have been observed regularly off east Scotland.

Sightings generally occur between April and November, with the peak number of records occurring in August. Strandings have occurred between November and March and individuals have also been observed off north-east Scotland and Shetland in winter, suggesting that the species may be present in the area year-round.

Risso's dolphin predominantly eat cephalopods, specifically octopus (*Octopoda*), cuttlefish (*Sepiida*) and various small squid (*Decapodiformes)*, but will occasionally eat small fish, including cod[25].

Eleven sightings of Risso's dolphins were recorded between 2024 and 2025 to SWF at various locations around Shetland. The closest sighting was of eight individuals at Breiwick, approximately 3 km south of the site. Other nearby sightings included four to eight individuals seen at Bressay Lighthouse (5 km southwest and south), and a group of four dolphins 18 km south of the site near Mousa. A single dolphin was observed 20 km southwest near South Havra. Further offshore, individuals and small groups were recorded 33–35 km from the site at locations such as Watsness, East of Biggings, and Sumburgh Head. The most distant sightings included groups of six and seven dolphins observed 50 km north at Tresta Wick and Wick of Tresta, respectively. As per sighting recorded to SWF, Risso's dolphins, the minimum recorded was 1 individual, while the maximum sighting was of at least 8 Risso's dolphins.

The most recent harbour porpoise abundance estimates for the assessment unit covering Shetland (North Sea (NS-E)) based on SCANS-IV data are 4,589 individuals (95% confidence interval: 31-16,458). Risso's dolphin density estimate for the North Sea (NS-E) block based on SCANS-IV aerial survey data is 0.0702 animals per km², with a mean group size of 15.5.

From the information gathered (number and locations of records), Risso's dolphin are considered to be present occasionally within the vicinity of the site and may be impacted by the works.

**Minke Whale**
Minke whale (*Balaenoptera acutorostrata*) is widely distributed in relatively small numbers, usually observed singly or in pairs. They tend to reside mainly on the continental shelf in water depths of 200 m or less, often being observed close to land, however, they have been recorded at depths of 500m. Minke whales are frequently seen in coastal and inshore waters and are widely distributed throughout the North Sea. The minke whale is the most frequently observed species in Shetland coastal waters. It is most often seen off north Unst, between the Out Skerries, Fetlar and Whalsay, and off the east side of Yell and Mainland. Most sightings occur between April and October, particularly from July to September[26].

Minke whales are both meso- and bentho-pelagic feeders, with those in the northern hemisphere mainly taking fish, including sandeel, herring, mackerel (*Scombrus scombrus*), sprat, capelin (*Mallotus*

[25] SWF, Risso's dolphin fact sheet (2020), available at: https://www.seawatchfoundation.org.uk/wp-content/uploads/2020/10/Rissos-Dolphin.pdf (Accessed 22/08/2025)
[26] Whales and dolphins - Cetaceans - Nature in Shetland, available at: https://www.nature-shetland.co.uk/whales-dolphins#:~:text=Minke%20Whale%20(Balaenoptera%20acutorostrata)&text=It%20is%20most%20often%20seen,particularly%20from%20July%20to%20September (Accessed 22/08/2025)

*villosus*), cod, whiting, haddock (*Melanogrammus aeglefinus*), but will also take euphausiids and copepods, especially at higher latitudes[27].

No sightings of Minke whale have been recorded within the proposed development area. However, fourteen sightings were reported to SWF between 2023 and 2025. A single individual was seen 6km southwest of the site at Kirkabister. Another was reported 12.5km southwest offshore of Hamnavoe. One sighting occurred 12km south of Aithsetter.

A whale was observed 30km northwest of Muckle Roe. One individual was recorded 30km northeast at Lunna Ness. Sightings of single whales were reported at locations such as Grutness, Compass Head, and Sumburgh Head, ranging from 33 to 35km away. Several sightings were also reported northeast of the site, including one to two individuals at Heoga Ness and Houbie Bay, 39 - 49km from the site. The most distant sighting was a single Minke whale recorded 49 km to the northeast.

In 2023, sightings of two minke whales were reported to ORCA by two individuals, with one sighting occurring southeast and the other northeast of the development site.

The most recent minke whale abundance estimates for the assessment unit based on SCANS-IV data are 12,417 individuals, with a 95% confidence interval ranging from 7,038 to 26,943. Equating to approximately 0.0085 animals per km, in Scottish waters. Although no density is shown immediately around the development area, predicted density around Shetland is generally within the range of 0.011–0.015 animals per km$^2$. (see the image below).

[27] Whales and dolphins - Cetaceans - Nature in Shetland, available at: https://www.nature-shetland.co.uk/whales-dolphins#:~:text=Minke%20Whale%20(Balaenoptera%20acutorostrata)&text=It%20is%20most%20often%20seen,particularly%20from%20July%20to%20September (Accessed 22/08/2025)

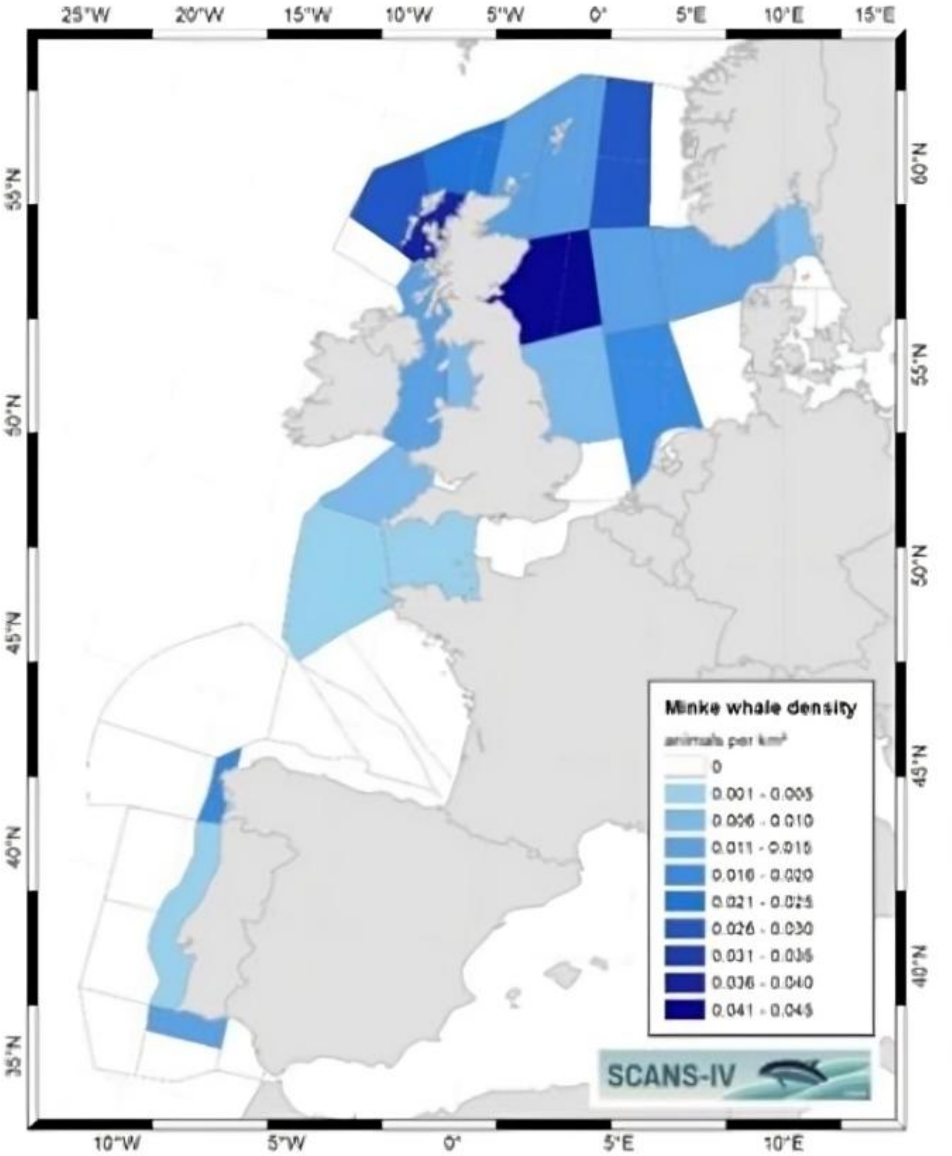


**Figure 3-2: Predicted density surface for minke whale in 2022 using SCANS IV survey data**

From the information gathered (number of records and locations of records) minke whale may be impacted by the works.

**Long-finned Pilot Whale**

Long-finned pilot whale (*Globicephala melas*) mainly occurs in deep waters (200-3,000 m), although it has occasionally been observed in shallower coastal waters around northern Scotland, the northern North Sea and the Channel. Long-finned pilot whales occur in greater numbers to the north of Scotland, with little seasonality in the pattern of sightings. Long-finned pilot whale are infrequently observed in nearshore waters, but sightings have been recorded year round, with no particular area favoured, although greater sightings are recorded between November and March, when several mass strandings have also occurred.

Long-finned pilot whale are benthic and pelagic feeders, with a diet consisting predominantly of squid, with some fish, including mackerel, hake (*Merluccius hubbsi*), cod, whiting, pollack (*Pollachius pollachius*), scad (*Selar crumenophthalmus*), sea bass (*Dicentrarchus labrax*) and sandeels [28].

No sightings of long-finned pilot whale have been recorded within the development area. Only one record of one long-finned pilot whale, approximately 22km southwest of the development site, was submitted to SWF in 2023. No other records of minke whale have been returned from other resources.

Estimates for the assessment unit based on SCANS-IV data are 3,314 individuals, with a 95% confidence interval ranging from 1,456 to 7,541. The estimated density for this species is 0.0023 animals per km² in Scottish waters. This figure includes both long-finned and short-finned pilot whales, as they could not be distinguished during the survey.[29]

From the information gathered (number and locations of records), long-finned pilot whale are considered to be present rarely within the vicinity of the site and are unlikely to be impacted by the works.

**Common Dolphin**

Common dolphin *(Delphinus delphis)* are recorded frequently in the North Sea and are fairly common and widely distributed around Shetland waters. In recent years, the species has occurred further north and east in shelf seas - around Shetland, and in the northern North Sea, reflecting changes in the strength of the Gulf Stream. The peak number of records of the species generally occur between July and October.

Common dolphin are mainly pelagic, opportunistic feeders consisting chiefly of small schooling fish. Other prey items include cod, scad, sandeel, herring, whiting and blue whiting, as well as squid, the type of food taken depending on local availability.[30]

No sightings of common dolphin have been recorded within the development area or within the wider area.

The most recent common dolphin abundance estimates for the assessment unit based on SCANS-IV data are 439,212 individuals, with a 95% confidence interval ranging from 309,153 to 623,987. The estimated density for this species is 0.259 animals per km² in Shetland.

From the information gathered (number and locations of records), common dolphin are considered to be present rarely within the vicinity of the site and are therefore considered unlikely to be impacted by the works.

**Killer Whale**

Killer whale (*Orcinus orca*) is widely distributed in the northern Scottish waters and specifically throughout Shetland waters. Killer whales are most commonly observed in coastal waters during the summer months (May to September), but they have been recorded throughout the year in Shetland. Groups ranging from 100 to 300 individuals have been sighted in the northern North Sea and east of Shetland, often associated with trawling activities.

[28] SWF, long-finned pilot whale fact sheet (2020), available at: https://www.seawatchfoundation.org.uk/wp-content/uploads/2020/07/Long-finned-Pilot-Whale.pdf (Accessed 22/08/2025)

[29] Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys (2023), available at: SCANS-IV design-based estimates (Accessed 22/08/2025)

[30] SWF, killer whale fact sheet (2020), available at https://www.seawatchfoundation.org.uk/wp-content/uploads/2020/07/Common-Dolphin.pdf (Accessed 22/08/2025)

Killer whale use a wide variety of foraging methods and thus have a very variable diet, including fish, such as herring, mackerel, salmon (*Salmo salar*), cod, halibut (*Hippoglossus stenolepis*), squid, rays (*Batoidea*), marine mammals, and occasionally turtles (*Testudines*) and birds[31].

No sightings of Killer whale have been recorded within the development area, however, records are available within the waters surrounding Shetland, inclusive of the following. Nineteen sightings were reported to SWF between 2023 and 2025 across various locations around Shetland. The closest sighting was of five individuals at Lerwick, approximately 2km south of the site. Several other nearby sightings included groups of four to five individuals at locations such as The Knab (3km south), Gletness (6.5km northeast), Eswick (11km northeast), South Nesting Bay (11km north), and Hamnavoe (12–12.5km southwest). A single individual was seen 11.3km southwest at Linga Island. Further offshore, groups ranging from one to three individuals were observed 24–39km from the site in areas such as off St Ninian's Isle, Wastness, Skaw (Whalsay), and North Skerries. The most distant sighting was a group of three killer whales recorded 47km northwest of the site near Eshaness. Sightings were also reported approximately 35 - 37km south at Sumburgh Head and the nearby lighthouse. For killer whales sightings submitted to SWF, the minimum recorded was two individuals, and the maximum was eight.

From the information gathered (number of records and locations of records) killer whale may present within the vicinity of the proposed development site occasionally and therefore could be impacted.

**Other Cetaceans**
Unusual cetacean sightings have included fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), White-beaked dolphin *(Lagenorhynchus albirostris),* Atlantic White-sided dolphin *(Lagenorhynchus acutus)*, and Beluga (*Delphinapterus leucas*).

However, these species are considered rare or occasional visitors to the area, and there are no known records of them occurring within the immediate vicinity of the proposed works. Given their infrequent presence and wide-ranging nature, it is considered highly unlikely that these species would be impacted by the proposed activities.

[31] SWF, killer whale fact sheet (2020), available at: https://www.seawatchfoundation.org.uk/wp-content/uploads/2021/03/Killer-Whale.pdf (Accessed 22/08/2025)

# 4 RESULTS AND ASSESSMENT

## 4.1 Activities Affecting Marine Mammals

## 4.2 Calculating PTS and TTS

**Dredging**

Research[32] conducted in Shetland recorded backhoe dredgers indicates source level noise within 1m as 163dB re 1µPa rms. The NMFS reported that for continuous (non-impulsive) noise, the TTS and PTS thresholds for marine mammals are:

- Very High-Frequency (VHF) Cetaceans (e.g., harbour porpoise): PTS = 197 dB, TTS = 177 dB
- High-Frequency (HF) Cetaceans (e.g., Risso's dolphin, common dolphin, killer whale): PTS = 201 dB, TTS = 181 dB
- Low-Frequency (LF) Cetaceans (e.g., minke whale): PTS = 181 dB, TTS = 161 dB

As such, the noise emitted by backhoe dredgers is under both the PTS threshold for all marine mammals and under TTS threshold for VHF and HF marine mammals, but within TTS threshold for LF marine mammals. It should also be noted that the continuous thresholds detailed above are based on animals staying in close proximity to the sound source for 24 hours, and the source level noise for the dredger is experienced within 1m. It is likely that once dredging commences, any individuals within the area will move away from the sound source fairly quickly. Therefore, the likelihood of dredging resulting in physical trauma or death to individuals is considered to be low.

In addition, from a review of other relevant projects, Aberdeen Harbour Expansion Project Environmental Statement[33] (AHEPES) the underwater noise from TSHD and BH dredging activities were modelled and identified the following for three species relevant to Lerwick North Harbour in relation to Cumulative TTS (TTS onset not considered worst-case scenario) and Level A-Auditory Injury (PTS as auditory injury onset and cumulative were not considered the worst-case scenario) (m) as seen in **Error! Not a valid bookmark self-reference.**.

**Table 4-1: Predicted significance of effects from underwater noise from dredging. Information obtained from Aberdeen Harbour Expansion Project Volume 2: Environmental Statement Chapter 15: Marine Mammals**

| Species | Effect | Range of Effect | Criterion |
|---|---|---|---|
| Harbour porpoise | Level A-Injury | 82m | 180 dB re 1 µPa (RMS) |
| | Cumulative TTS | >10km (BHD) | 164.3 dB re 1 µPa2 s |
| Risso's Dolphin | Level A-Injury | 82m | 180 dB re 1 µPa (RMS) |
| | Cumulative TTS | 350m | 195 dB re 1 µPa2 s |
| Minke Whale | Level A-Injury | 82m | 180 dB re 1 µPa (RMS) |
| | Cumulative TTS | 350m | 195 dB re 1 µPa2 s |

For all of the above it was considered that individuals are expected to be able to avoid adverse noise arising from the dredging by simply moving out of these areas before the onset of significant injury or mortality and in relation to TTS, it would likely result in avoidance and temporary displacement of

[32] Todd, V. L. G., Todd, I. B., Gardiner, J. C., Morrin, E. C. N., MacPherson, N. A., DiMarzio, N. A., and Thomsen, F. A review of impacts of marine dredging activities on marine mammals. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu187
[33] Microsoft Word - 01 Introduction to the Proposed Development FINAL.docx

cetaceans from these areas for the duration of dredging activities. These effects are temporary and not a permanent loss of hearing. Individuals would be expected to forage in adjacent waters for these periods. Although TTS and PTS threshold levels in relation to dB for marine mammals differ within this report to updated findings from NMFS, the assessment is not considered to change. This would be considered the same outcome for Lerwick North Harbour.

In addition, although the harbour porpoise TTS range is predicted to occur up to 10,000m in relation to BHD activity, this species is recognised as being highly adaptable with the ability to forage over wide areas, thus, it would not be anticipated to cause significant energetic consequences or detrimental effects on foraging ability, which could lead to mortality. Harbour porpoise have an abundant and widely distributed North Sea population, and therefore significant effects are not anticipated in respect of displacement.

### 4.2.1 Drilling

Drilling through hard sediment can be significantly noisy, and given that drilling will be part of the wider blasting activity and will occur up to 24 hours a day and a 7 day a week basis, the noise from drilling will not be dominated by the acoustic impact of the blasting. Drilling will be undertaken for up to approximately 90 holes per field, during which there would likely be a noise increase in the water environment over 2.5 weeks, weather depending, and may be undertaken partly in winter.

The noise that drilling generates is considered to vary mainly depending on bed substrate type being drilled, with some drilling noise levels for underwater being found to range up to approximately 190dB re 1μPa rms[34], whilst a detailed analysis of underwater noise during offshore exploratory drilling found noise levels to be 155.9dB re 1μPa rms[35].

In addition, in underwater noise modelling undertaken for Hatston[36] in Orkney (a recent harbour extension site) by Irwin Carr, for a site which is expected to have 10 holes drilled per day included a summary of 13 different recorded drilling episodes showing noise levels to vary considerably between sites and equipment, and there is no clear connection between drill size, power or sediment type to the emitted noise level (as seen in Figure 4-4).

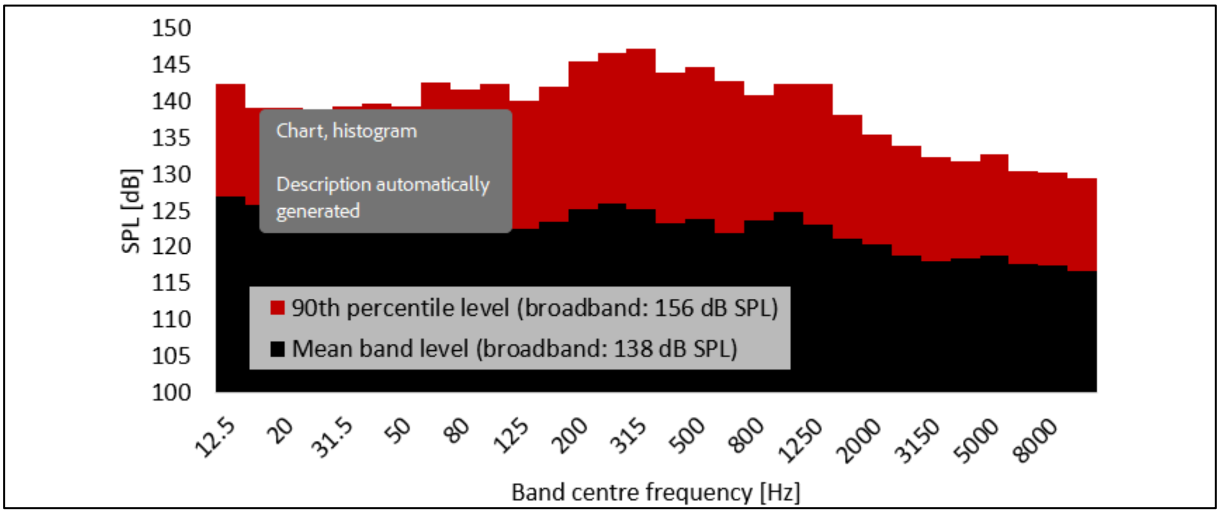


**Figure 4-4: Example of drilling noise band levels. Data from various drills, diameter 0.1-1.2 m and various rock types. Figure obtained from Irwin Carr UWNM report**

[34] OSPRA Commission, Assessment of environmental impact of underwater noise (2009)
[35] Huang L-F, Xu X-M, Yang L-L, Huang S-Q, Zhang X-H and Zhou Y-L (2023) Underwater noise characteristics of offshore exploratory drilling and its impact on marine mammals. *Front. Mar. Sci.* 10:1097701. doi: 10.3389/fmars.2023.1097701
[36] RP001 Rv3 2022248 (Hatston Pier UW Modelling)

Drilling has a broadband level of 156 dB SPL at the 90th percentile, which will mean that its impact to the marine environment is minimal.

Drilling activities, such as those associated with boreholes or rock socket installation, generate continuous low- to mid-frequency underwater noise. According to JNCC guidelines, noise from drilling in shallow coastal environments may be detectable by marine mammals within short distances; however, the sound levels generally attenuate rapidly with distance and are unlikely to result in injury. As such, drilling is unlikely to cause permanent or temporary auditory injury. Nonetheless, behavioural responses such as avoidance or altered foraging may still occur (general disturbance). To minimise this risk, mitigation measures such as Marine Mammal Observers (MMOs), PAM and soft-start protocols ahead of works will reduce general noise disturbance from drilling to marine mammals.

### 4.2.2 Blasting

The charge per holes at Lerwick North Harbour will commence at 20kg MIC[37] and will be undertaken within the parameters identified in the trial blasting, described in section 1.5.2. It is also estimated that 9-90 holes will be drilled in for each field. Charges will go off at the beginning and end of each day (daylight). This would occur over a 5 week period. As part of an overall mitigation of blast noise impact intensity then the contractor is proposing to use 25 millisecond blast delays[38] between each charged hole to help minimise the MIC / Qmax value for each overall blast. This means that the number of charges detonated alone does not necessarily relate to the overall blast noise level. It is also worth noting that the noise (peak sound pressure) of each blast will only be as high as that of the largest (loudest) detonation in each blast sequence. Subsequent detonations in the sequence, which are of equal or lesser noise level, will not add to the overall noise of the blast, although the time component of the blast event will increase.

The Subacoustech[39] report (see Appendix B) assessed MIC values up to 130kg and total charge weights up to 700kg based on predictions using Soloway and Dahl (2014)[40] calculations and was then compared to a real-world project at Singapore Harbour 2024[41].

Following the prediction in Soloway and Dahl (2014), (which includes a correction for explosives in rock noted in MTD 96/101[42]), a noise level of 191.6 dB $SPL_{peak}$ at 1000m from a blast with a MIC up to 130kg is predicted, which is substantially below the threshold of instantaneous PTS onset for harbour porpoise of 202 dB $SPL_{peak}$. The estimated distance at which 202 dB $SPL_{peak}$ is predicted for harbour porpoise to occur is approximately 350m from the blast location using this methodology. A total charge weight of 700kg (including the 30% correction for embedded charges) leads to a noise level of 165 dB SEL (VHF weighted, as per Southall *et al*., 2019[43]) at 1000m, considered to be in excess of the 155 dB SEL limit for PTS onset in harbour porpoise[44] (155 dB SEL is estimated at 2.4 km).

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[37] The total charge mass of explosives firing at one instant during a blast, a key measure in managing blasting vibration.
[38] Colin Fergusson who is advisor to contractors who completed the drilling and blasting method statement advised that 25 millisecond delays between charges are regarded as individual blasts and therefore minimise the MIC/ Qmax overall.
[39] *Subascoustech report P438LR0102*
[40] Soloway and Dahl (2014) sets out calculations for the prediction of noise from detonations of explosives underwater, with a specific focus on UXO (i.e. unconstrained detonation in the water column)
[41] Mason T and Morgan I (2024) *Underwater noise monitoring, drilling and blasting in Temasek Fairway, Singapore*. Subacoustech report ref. P398R0102
[42] MTD 96/101 also states that the explosive peak pressure of explosions in rock reduces to approximately 5% of the value for freely suspended charges, or 30% for total exposure
[43] Southall B L, Finneran J J, Reichmuth C, Nachtigall P E, Ketten D R, Bowles A E, Ellison W T, Nowacek D P, Tyack P L (2019). *Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects.* Aquatic Mammals 2019, 45 (20, 125-232) DOI 10.1578/AM.45.2.2019.125.
[44] Note that criteria for PTS onset based on the instantaneous SPLpeak threshold use the NMFS (2024) guidance, whereas the SEL criteria use the older Southall *et al.* (2019) guidance. This is because the SPLpeak thresholds are straightforward to update, whereas the species-weighted SEL thresholds would require considerable reanalysis of the Singapore data to update and

When the theoretical calculation is compared to real-world measurements in Singapore, it suggests that charge weights with a MIC of >30kg will result in AUD INJ threshold distances outside the mitigatable 1000m range for harbour porpoise (see Figure 4-1[45]). Thresholds for all other species hearing groups are in excess of 222 dB $SPL_{peak}$ and are not exceeded.

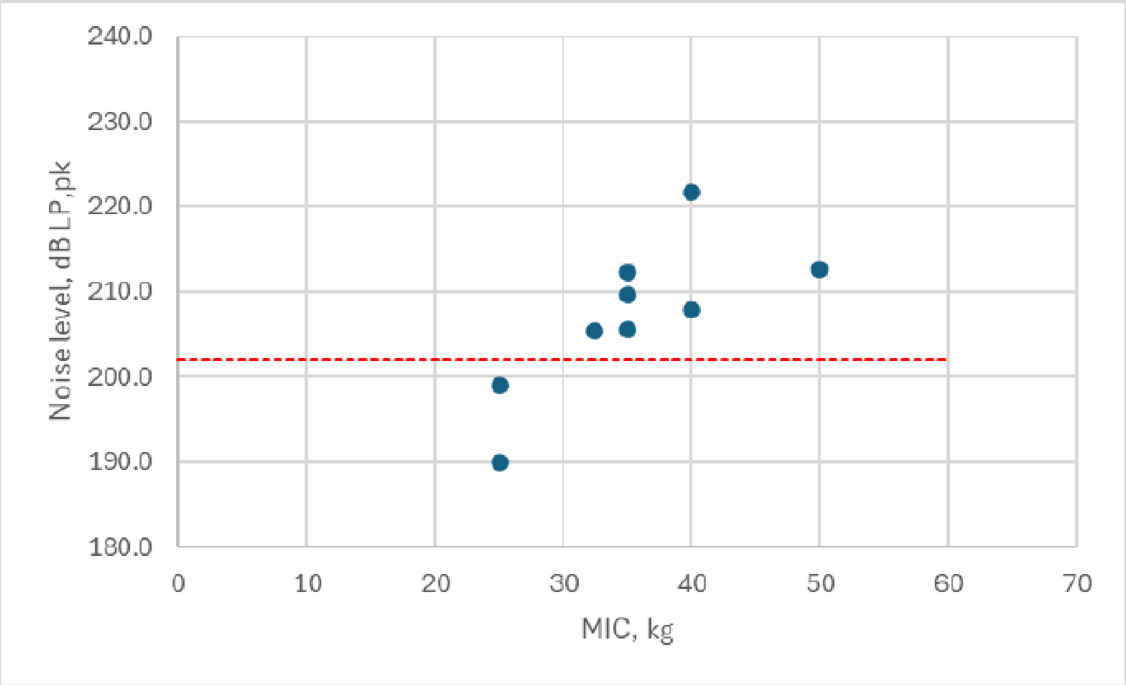


**Figure 4-1: Shows the $SPL_{peak}$ measurements against MIC size, normalised to 1000m with harbour porpoise instantaneous PTS threshold marked (202 dB $SPL_{peak}$, as per NMFS, 2024 threshold). Figure obtained from the Subacoustech report**

Harbour porpoise, have the greatest sensitivity to noise due to their high-frequency hearing ranges. Using both theoretical and empirical measurements, the Subacoustech report indicates that the larger MICs (>30kg) and total exposures would exceed the harbour porpoise PTS threshold at 1km for all except the theoretical instantaneous calculation ($SPL_{peak}$). The real-world measurements from Singapore Harbour indicate that there could be a risk of PTS >1000m for charges exceeding 30kg MIC.

Due to similarities in parameters, the results from Singapore Harbour may closely mirror the required works at Lerwick North Harour. Therefore, it is considered possible that PTS could be <1000m at ≤30kg (for harbour porpoise). However, the noise produced from blasting is based on a worst-case scenario, and other factors, such as local geological conditions, hole drill depth, hole geometry, water depth and water stratification can also influence noise levels propagating from each blast[46]. Such variables further limit the consideration of the effect of charge numbers on blast noise levels alone. In addition, the real risk to harbour porpoise should not be overestimated either, due to the small population in the area (based on baseline data) and the low likelihood of an individual being present near the blast sites, due to the elevated noise levels from drilling prior to blasting. Additionally, the findings from trial blasting will better confirm these parameters for the Lerwick North Harbour site.

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enable a direct comparison. Subacoustech's analysis previously of the difference between marine mammals criteria in Southall *et al.* (2019) and NMFS (2024) indicate that the overall difference between the two criteria is relatively small.

[45] The results shown in the figures were obtained from the measurements at Singapore Harbour. A range of distances were sampled, between 580m and 2000m (most at 800m to 1000m), and the measurements were normalised using a simple acoustic principle (15.log[r]), as if all measurements were sampled at 1000m and the only variable was the charge weight.

As the blasting has no slow build-up of noise or soft-start and leaves no time for marine mammals to vacate the area, mitigation will be put in place to ensure marine mammals are clear of the area prior to blasting. Working within the charge and mitigation buffers identified in the trial blasting and implementing MMOs, use of PAM, and, if required, ADD to ensure marine mammals are clear of the area prior to blasting would reduce the likelihood of auditory impacts occurring to marine mammals. In addition, as drilling will occur continuously between blasts, there will be a constant noise source occurring within the vicinity of the blasting area, and this will likely discourage marine mammals from using the area of works ahead of blasting occurring.

### 4.2.3 ADD

ADDs are devices consisting of a control unit and a transducer (sound head). The control unit contains a pulse generator and an amplifier and transmits random bursts of audio frequency signals to the transducer, where they are converted into sound. ADDs were originally developed for the aquaculture industry to deter marine mammals, largely seals, from fish farms. Therefore, marine mammals display avoidance reactions to these sounds. However, ADDs have been widely applied to reduce the risk of injury to marine mammals during pile-driving at offshore wind farms or for UXO clearance activities.

A JNCC Report[47] which acts to provide a collated reference for Statutory Nature Conservation Bodies (SNCBs), including NatureScot, Natural Resources Wales and Natural England, to inform advice in relation to marine industries on the use of ADDs to deter marine mammals from areas where there is a risk of injury or death for a range of ADDs.

For example, Ace Aquatec: Midfrequency Acoustic Startle Response Device (US3) (formerly Universal Scrammer) is reported[48] to have deterrence ranges of between 200m and 1.2km for harbour porpoise with a potential exclusion up to 6km (and modelling suggests potential for audibility range between 33.5-68km in sea state 6-0), with an evidence score of 3 – High Confidence[49], whilst Ace Aquatec: MMD High Frequency has deterrence ranges for harbour porpoise between 50-6km, based on modelled exclusion with the potential to cause mortality or injury I close proximity (1-3m), with an evidence score of 2 – Medium Confidence[50].

For LF cetaceans (e.g. minke whale), Lofitech: seal scarer has deterrence ranges for minke whale of 1000m, with an evidence score of 3 – High Confidence, whilst for general LF cetaceans Ace Aquatec: MMD Low Frequency has deterrence ranges of 50-1000m, with displacement measured >1km depending on the species, with sound detectable at 7km, and with an evidence score of 2 – Medium Confidence.

Therefore, it is essential to determine the appropriate ADD is to be used to ensure marine mammals are deterred from entering PTS risk ranges during works.

As ADDs emit noise levels that deter the target species from a certain area, there are concerns that some of the louder ADD devices may have the potential to result in PTS onset, particularly from accumulated exposure to the sound. JNCC developed a simple empirical model in the original 2022 report (Version 4) (McGarry et al. 2022) to estimate the received cumulative Sound Exposure Level

[47] Phillips, B, Roberts, A., Buckland, L., Canning, S., Goulding, A., Mendes, S., Prior, A., De Silva, R., Stephenson, S., & McGarry, T. (2025) Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 5). JNCC Report 615. JNCC, Peterborough. ISSN 0963-8091. https://hub.jncc.gov.uk/assets/e2d08d7a-998b-4814-a0ae-4edf5d887a02
[48] Deterrence ranges reported in the literature and/or manufacturer's information are likely to be influenced by factors such as local propagation characteristics, as well as animal's motivation, previous exposures to device and background noise levels
[49] Evidence Score is not a measure of the effectiveness of an ADD but is an assessment of confidence in the evidence for an ADD's effectiveness. Evidence score 3 requires to be backed up by at least one peer reviewed study
[50] Medium confidence score requires to be backed by non-peer reviewed/grey literature

(SELcum) that marine mammals swimming away from a single active ADD could be exposed to[51], to investigate the potential for auditory injury due to ADD. Sound exposure calculations were based on a set of simplistic assumptions, and that real-world sound propagation is more complex, thus, the modelling is required to be treated as an indicative, risk-based approach rather than a definitive statement or assessment as to whether there is potential for any ADD in any situation to cause injury. The modelling found the NOAA (2018) PTS onset threshold (i.e. hearing frequency weighted SELcum) for all mammals was not exceeded beyond a range of 100 m for any of the modelled devices (except one), although, according to the model, it is theoretically possible that PTS could occur in VHF cetaceans (e.g. harbour porpoise at a range of up to 130 m). To support these results, a comprehensive review of peer-reviewed literature was undertaken, which found ADDs do have the potential to induce auditory injury in marine mammals[52] , and that injury in marine mammals may be avoided by the judicious and proportionate use of ADDs.

JNCC also states that using devices which have the potential to exclude animals from the mitigation zone should be considered. However, ADDs should only be implemented in conjunction with visual and/or acoustic monitoring (PAM) and for as short a period as necessary to minimise the introduction of additional noise.

As such, it is considered that although there are some risks of ADDs affecting marine mammals negatively, the risk of PTS occurring can be avoided/ and the risk of physical injury or death greatly reduced by utilising ADDs proportionately to ensure marine mammals are not present within 1000m of the noise source.  The mitigation section identifies appropriate systems and protocols for ADD use.
The mitigation section identifies appropriate systems and protocols for ADD use.

## 4.3 Calculating Individuals to be Impacted

The Marine Scotland 'Guidance for Scottish Inshore Waters: The Protection of Marine European Protected Species from Injury and Disturbance[53] defines what disturbance means to marine mammals as: 'Changes in behaviour which may not appear detrimental in the short-term but may have significant long-term consequences. Additionally, the effects may be minor in isolation but may become more significant in accumulation. Disturbance may be identified via the following behaviour:

- Changes in (direction or speed of) swimming or diving behaviour;
- Bunching together or females shielding calves;
- Certain surface behaviours such as tail splashes and trumpet blows; and
- Moving out of a previously occupied area.

The following negative effects are linked to disturbance:

- Displacement from important feeding areas;
- Disruption of feeding;
- Disruption of social behaviours such as communication, calving, breeding, nursing, resting and feeding; and
- Increased risk of injury or mortality;

[51] The modelling undertaken as part of the original 2022 report (Version 4) assumed a generalised swim speed of 2.5 m s-1 (a single swim speed was applied to cover a range of assumptions and species) and utilised the source noise data, frequency and pulse rate specific to each ADD available at the time of modelling. The modelling assumed 30 minutes of activation and is based on a simplistic 15 log R propagation assumption.
[52] The focus of these studies is on the continuous activation of devices (SELcum) over 24 hours, rather than in the context of SPLs.
[53] https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/07/marine-european-protected-species-protection-from-injury-and-disturbance/documents/marine-european-protected-species-guidance-july-2020/marine-european-protected-species-guidance-july-2020/govscot%3Adocument/EPS%2Bguidance%2BJuly%2B2020.pdf

- Increased vulnerability of an individual or population to predators or physical stress; and
- Changes to regular migration pathways to avoid human interaction.

The NMFS predicts that marine mammals are likely to be behaviourally harassed when exposed to underwater noise levels of 120dB during continuous sources such as vibratory piling or drilling, and 160dB for non-explosive, impulsive sources, such as impact pile driving, whilst for underwater explosive sources where multiple detonations occur within a 24 hour period, the behavioural threshold is -5dB from TTS onset.

Overall, it is expected that marine mammals would be likely to exhibit a behavioural change as a result of the noise, as detailed above. In addition, physiological stress is likely to also occur. This could impact marine mammals' energy and fitness levels through disturbing foraging or causing avoidance of feeding areas for periods of time.

### 4.3.1 Individuals Impacted (Quantitative Data) – Disturbance

Although the NMFS predicts 160 dB $SPL_{rms}$ for impulsive noises, crucially, this threshold is not intended for explosive noise. However, in their Summary of Acoustic Thresholds (2025)[54], NMFS provides a series of weighted SEL behavioural thresholds for explosions considering multiple detonations for relevant species groups. As such, Subacoustech detailed these thresholds alongside the calculated result for a selection of charge weights (with embedded charge correction)[55].

**Table 4-2: Behavioural thresholds for underwater explosives, NMFS (2025) and predicted impact ranges. Note these use the NMFS (2024)[6] marine mammal weightings and linked thresholds, dB re 1 μPa$^2$s**

| Hearing Group | Example species | Threshold, weighted | 20 kg | 30 kg | 50 kg | 700 kg |
|---|---|---|---|---|---|---|
| LF Cetaceans | Minke whale | 163 dB SEL | 20 km | 24 km | 30 km | 93 km |
| HF Cetaceans | Risso's dolphin | 173 dB SEL | 110 m | 140 m | 170 m | 520 m |
| VHF Cetaceans | Porpoise | 139 dB SEL | 3.4 km | 3.6 km | 3.9 km | 5.4 km |

The long-range results calculated for LF cetaceans are considered likely to be a significant over-estimation of the real risk, due to the relatively shallow water at the Lerwick North Harbour site which will likely attenuate the noise more quickly than the calculation assumes. It is also worth being mindful of the context: a widespread clearance of an area would be much more likely where high noise levels are present for an extended period. For a single detonation (effectively also a single collection of detonations) lasting less than a second, with many hours between the explosive events, it is hard to localise the sound and so this is thought most likely to lead to a startle reaction in individuals rather than causing a displacement of marine mammals. Furthermore, the works to be undertaken are short term and temporary in nature, which will likely limit disturbance. In addition, as harbour porpoise are considered to be the most sensitive to noise, and for this species, PTS at 1000m may be exceeded with a MIC >30kg, that a 3.6km buffer for disturbance would be most suitable and would cover noise related behavioural responses. A buffer of this distance is applied to the application site boundary, and only the area (km$^2$) 'at sea' is taken.

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[54] https://www.fisheries.noaa.gov/s3/2025-09/MM-Acoustic-Thresholds-508-secure-SEPT-2025-OPR1.pdf

[55] "Level B" criteria are normally 160 dB for impulsive noise and 120 dB for non-impulsive noise – but the 160 dB threshold has an exclusion for explosive noise. There are separate thresholds for these (and all are lower than what 160 dB would be)

Based on the methods in Section 2.3.1 the estimated number of individuals that could be disturbed for marine mammals is presented in Table 4-3.

**Table 4-3: Individuals Impacted (General Disturbance)**

| Species | Step 1: Maximum Disturbance Buffer and 'at sea' area km$^2$ | Step 2: Density Estimates | Step 3: Individuals within 3.6km |
|---|---|---|---|
| Harbour porpoise | 3.6km (25.53km$^2$ at sea) | Scans IV density estimates are up to 0.4-0.77 individuals per km$^2$ (average 0.6) | 0.6 x 25.53 = 15.31<br>**16 individuals** |
| Risso's dolphin | 3.6km (25.53km$^2$ at sea) | Scans IV density estimate is 0.0702 per km$^2$ | 0.0702 x 25.53 = 1.79 **2 individuals** |
| Minke whale | 3.6km (25.53km$^2$ at sea) | Scans IV density estimates are 0.011–0.015 per km$^2$ (average 0.013) | 0.013 x 25.53 = 0.33 **1 individual** |
| Killer whale | 3.6km (25.53km$^2$ at sea) | No Scans IV density estimate. Maximum number reported at one time in recent years = 8 | **8 individuals** |

Based on the estimated number of individuals that could be disturbed in Table 4-3, the percentage in relation to the SCANS IV abundance estimates has been devised[56]:

- Based on the estimated number of individual harbour porpoise that could be disturbed, equating to 16, in relation to the SCANS IV abundance estimates for harbour porpoise being 33,8918, this would only result in 0.005% of the total number of harbour porpoises estimated for the covering Shetland.
- Based on the estimated number of individual Risso's dolphin that could be disturbed equating to 2, in relation to SCANS IV abundance estimates for Risso's dolphin being 4589, this would only result in 0.042% of the total number of Risso's dolphin estimated for the covering Shetland.
- Based on the estimated number of individual minke whale that could be disturbed equating to 1, in relation to SCANS IV abundance estimates for minke whale being 12417, this would only result in 0.008% of the total number of minke whale estimated for the covering Shetland.

## 4.4 Effects of Increased Vessel Movement

Increased vessel movement has the potential to increase collisions with marine mammals.

The works will include associated vessel movements with dredging itself, blasting and drilling and then barges moving between the dredge site and the disposal site.

Movements associated with the drill and blast campaign are four to five barges per 24 hours over 5 weeks equating to approximately 55 to 70 total vessel movements. Vessel activity related to explosive

[56] No abundance data for Shetland in relation to killer whales was available and so therefore this could not be calculated

delivery will only involve two trips. However, although there will be an increased in dredging vessel activity, no port activity will take place whilst dredging is carried out, and therefore, there will be an offset with a reduction in normal harbour vessel activity.

The works will require a number of vessels that will be of consistent size, speed and operating procedure. However, this can still result in marine mammal collision risk associated with the Lerwick North Harbour Capital dredge campaign activities. Larger vessels have a greater footprint and, therefore, are more likely to make encounters with marine mammals than smaller vessels.

Larger whales (predominantly Baleen whales) are most often reported in regard to vessel collisions. In general, larger whales are less manoeuvrable than smaller cetaceans and therefore, may be a likely attribute to vessel collision. For example, minke whales have reportedly been killed by ship strikes in UK waters. However, whales are observed much less frequently in the vicinity of Lerwick North Harbour.

Harbour porpoises often live in the vicinity of vessel traffic, and reactions by porpoises to various types of vessels showed only short-term negative effects from speedboats and large ferries in a study by the Sea Watch Foundation[57]. HWDC[58] indicate that as harbour porpoise are naturally shy of boats, they will for the most part avoid them, and so for most types of marine traffic, the risk of collision is minimal. There is more potential for collision with fast-moving engine-powered vessels due to their speed and ability to change direction quickly.

Risso's dolphins are rarely seen approaching vessels or bow-riding, suggesting that this species may actively avoid vessel traffic.

Killer whales are generally inquisitive and are observed approaching vessels, however, like other smaller cetaceans (white-beaked dolphin and pilot whales), they are fast, agile and manoeuvrable in water.

The likelihood of vessel collisions is dependent upon vessel speed, animal behaviour and vessel manoeuvrability[59]. Vessels travelling at slower speeds in general can allow time for marine mammals and vessel operators to react to avoid collisions. Dredging vessels are relatively slow moving and follow established routes therefore, the risk of collision is likely to be further reduced.

However, the Lerwick North Harbour is already part of an established port and the site is within a highly trafficked area for vessels, and the area within the proposed works is not estimated to be an area with a particularly high usage by marine mammals for foraging. As such, it is considered that marine mammals utilising the waters within this area would likely avoid or be accustomed to the regular movements of vessels and thus the likelihood of vessel strike may be lower.

Although vessel strike is considered highly unlikely during the construction phase, a vessel management plan should be implemented which details measures to reduce disturbance related impacts.

[57] Sea Watch Foundation: The Harbour Porpoise in UK Waters available at: http://seawatchfoundation.org.uk/wp-content/uploads/2012/07/Harbour_Porpoise.pdf (Accessed 22/08/2025)
[58] HWDC Harbour Porpoise information available at: https://hwdt.org/harbour-porpoise (Accessed 22/08/2025)
[59] SEER U.S. Offshore Wind Synthesis pf Environmental Effects Research: Presence of Vessels: Effects of Vessel Collision on Marine Life (2022): https://tethys.pnnl.gov/sites/default/files/summaries/SEER-Educational-Research-Brief-Effects-of-Vessel-Collision-on-Marine-Life.pdf

## 4.5 Conclusion

Some of the activities associated with the works (dredging, blasting and drilling) have the potential to cause disturbance, injury or in extreme circumstances, death to individual marine mammals. For the most part, the activities associated with the proposed development will result in the temporary avoidance of a small area of habitat available to individuals. PTS ranges are considered to lie within 1000m, which can be mitigated through the use of the MMO, PAM and ADD, where required, to ensure marine mammals are clear of the area prior to works occurring.

The increase in the number of vessels travelling through to Lerwick North Harbour during works could increase the risk of collision with marine mammals, potentially resulting in death or injury to individuals. However, Lerwick North Harbour is already part of an established port, and due to the high number of vessels utilising the area already, the likelihood is reduced.

The quantitative data show that a maximum of 16 harbour porpoises, 2 Risso's dolphin, 1 minke whale and 8 killer whales could be disturbed from noise related activities. These numbers are considered a 'worst case' scenario due to the disturbance range of the most sensitive marine mammals (harbour porpoise) being used to determine the buffer distance (3.6km). Therefore, the actual numbers would likely be lower, and when compared to the abundance estimates for Shetland, are considered very low. Thus, the potential for disturbance is considered to be limited.

Overall, the project may result in marine mammals avoiding the works area during works, and behavioural changes may occur out to 3.6km, however from the implementing of trial drilling and blasting mitigation, with the inclusion of PAM and MMOs, it is considered that the risk of death and injury this will be greatly decreased, the distance of disturbance to marine mammals will be reduced.

# 5 MARINE MAMMAL MITIGATION PLAN

The Marine Mammal Mitigation Plan (MMMP) will comprise a standard Marine Mammal Observer (MMO) protocol as per JNCC guidance (and therefore takes into account all cetaceans and pinnipeds) to be implemented during the trial drilling and blasting and during operations in optimal sea states less than 4 and during times of optimal visibility.

## 5.1 Marine Mammal Observation Protocol

The Marine Mammal Observation Protocol (MMOP) will be implemented so that the blasting, drilling and dredging works do not cause injury or unnecessary disturbance to marine mammals. This section has been designed with reference to the current JNCC guidance 'Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise' (August 2010) [60] and 'Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from explosives' (January 2025) [61] [62].

## 5.2 Marine Mammal Observer

A minimum of two suitably qualified Marine Mammal Observer (MMO) (as per guidance), competent in the identification of marine mammals at sea, will be present during the drilling and blasting works. The MMOs will undertake observation for marine mammals within the mitigation zone before and will be dedicated to that one task for the duration of any watch. The MMOs will advise the contractors and crews on the implementation of the procedures set out in the agreed protocol, to ensure compliance with those procedures.

The JNCC guidance provides the following definitions of an MMO:

**MMOs**: An individual responsible for conducting visual watches for marine mammals. It may be requested that observers are trained, dedicated and/or experienced.

**Trained MMOs**: Has been on a JNCC recognised course.

**Dedicated MMOs**: Trained observer whose role on board a vessel is to conduct visual watches for marine mammals.

**Experienced MMOs**: Trained observer with three years of field experience observing for marine mammals, and practical experience of implementing the JNCC guidelines.

The MMOs will be trained. The identity and credentials of the MMOs will be agreed with the Marine Directorate.

[60] https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf

[61] https://data.jncc.gov.uk/data/24cc180d-4030-49dd-8977-a04ebe0d7aca/jncc-guidelines-marine-mammals-and-explosive-use.pdf

[62] It should be noted that these protocols do not document measures to mitigate disturbance effects but have been developed to reduce to negligible levels of risk of injury or death to marine mammals in close proximity to piling operations or explosives.

## 5.3 MMO Equipment

The MMOs will be equipped with binoculars (10X42 or similar) and/or a spotting scope (20-60 zoom or equivalent), a copy of the agreed protocol and the Marine Mammal Recording Form (MMRF), which is a Microsoft Excel spreadsheet containing embedded worksheets named Cover Page, Operations, Effort and Sightings. A Microsoft Word document named Deck forms is also available, and the MMOs may prefer to use this when observing before transferring the details to the Excel spreadsheets. The ability to determine the range of marine mammals is a key skill for MMOs, therefore, a hand-held rangefinder will be used to verify the range.

All MMO forms, including a guide to completing the forms; and instructions on how to make a rangefinder, are available on the JNCC website: https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/Marine-mammal-recordingforms-guide-piling-rev05.pdf and https://hub.jncc.gov.uk/assets/24cc180d-4030-49dd-8977-a04ebe0d7aca.

### 5.3.1 Communication

The contractor will be responsible for the communication channels between those providing the mitigation service and the crews working on the drilling and blasting vessel. A formal chain of communication from the MMOs to the contractor, who will start/stop the works, will be established. In order to confirm the chain of communication and command, the MMOs will attend any relevant pre-mobilisation meetings.

### 5.3.2 Mitigation Zone

As part of the drilling and blasting trial, MMOs will monitor the area at both 500m and 1000m with the support for PAMs and noise monitoring equipment, analysing the data to determine TTS and PTS associated with the blasting. JNCC guidance recommends a 1,000 m exclusion zone for underwater blasting, however, this distance may be impractical in the context of the site due to spatial and operational constraints and is considered precautionary. The suitability of this will be determined by evaluation of the trial blast underwater noise monitoring as detailed within the drilling and blasting method statement[63] [64]. Depending on the outcome of this, it is considered that there may be potential for the mitigation zone to be reduced, in discussion with the MMOs. If the size of the mitigation zone is adjusted for any reason, this will be stipulated within the works consent or licence conditions and must be agreed with statutory bodies before being implemented.

During the works, the MMOs will therefore monitor the agreed mitigation zone and advise if any marine mammals are within it.

### 5.3.3 Passive Acoustic Monitoring (PAM)

In addition to MMOs, PAMs should be provided throughout the operation to supplement visual checks.

PAM are software systems that utilise hydrophones to detect the vocalisations of marine mammals. This will help aid in the detection of species which are less easily detected at the surface via MMOs or during unfavourable conditions.

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[63] Lerwick Port Authority – Lerwick Harbour & Dales Voe Dredging, Drill & Blast Dredging Trial Blast – Proposed Underwater Acoustic Monitoring Method Statement (2025).pdf
[64] Subacoustech Environmental Outline Proposal (2025).pdf

Visual observation is an ineffective mitigation measure during periods of darkness or poor visibility (such as fog), or during periods when the sea state is not conducive to visual mitigation, as marine mammals in the vicinity of blasting will not be detected. JNCC views PAM as the only available mitigation technique that can be used under these conditions, and that it can also be used to enhance the detection of certain marine mammal species[65].

Specialist PAM operatives are needed to set up and deploy the equipment and interpret the detected sounds. The PAM hydrophones should be situated as close as possible to the site of blasting, and sacrificial hydrophones may therefore be required.

Hydrophones deployed from standby vessels can be used for acoustic monitoring, but a disadvantage of these systems is that they will move away from the site of blasting when the vessel moves and may then be too far away to detect any marine mammal vocalisations within the mitigation zone. Remotely operated static PAM systems, which can be left at the initial blasting site, may be an option, but they may not always be commercially available or best suited for operations in shallow coastal environments.

PAM can provide a useful supplement to visual observations undertaken by MMOs. However, in many cases, it is not as accurate as visual observation for determining range, and this will mean that the mitigation zone will reflect the range accuracy of the system. Some PAM systems do not have a reliable range determination facility or can only calculate the range for some species. In such cases, the detection of a confirmed cetacean vocalisation should still be used to initiate postponement of the drilling soft-start or blasting works, if the PAM operator is able to make a judgement about the range of the marine mammal (dependent on species) from the works, because of experience gained in differentiating between distant and close vocalisations. In the absence of PAM systems capable of range determination, this expert judgement will constitute the basis for deciding whether an area is free from marine mammals prior to the drilling soft-start or blasting.

PAM operators will submit a method statement and details of the equipment to be used to MD-LOT for approval before the equipment is deployed.

## 5.4 MMO Protocol

1. A standard MMO protocol as per JNCC guidance is to be implemented during operations in sea states less than 4 and during times of optimal visibility.

2. Visual monitoring will not commence during poor visibility (such as fog) or during periods when the sea state is not conducive to visual mitigation (above sea state 4 is considered not conducive[66]), as there is a greater risk of failing to detect the presence of marine mammals. Harbour porpoise have small dorsal fins, therefore, the MMOs shall take additional precautions if the sea state exceeds 2. An elevated platform for the MMOs to monitor from would be beneficial.

3. The MMOs will likely be onboard the works vessel, or a land-based platform, that provides the best viewing platform, that allows 360 degree visual cover, and is likely to be closest to the works activities.

4. The mitigation zone will be monitored visually by the MMOs for an agreed period prior to the commencement of any works. This will be a minimum of 60 minutes for blasting.

5. The MMOs will scan the waters using binoculars or a spotting scope and by making visual observations. Sightings of marine mammals will be appropriately recorded in terms of date, time,

[65] JNCC guidelines for minimising the risk of injury to marine mammals from explosive use in the marine environment 2025, available at: https://hub.jncc.gov.uk/assets/24cc180d-4030-49dd-8977-a04ebe0d7aca (Accessed 22/08/2025)
[66] Detection of marine mammals, particularly porpoises, decreases as sea state increases.

position, weather conditions, sea state, species, number, adult/juvenile, behaviour, range, etc., on the JNCC standard forms. Communication between the MMOs and the contractor and the start/end times of the activities, will also be recorded on the forms.

6. Drilling and Blasting activities should not be undertaken within 20 minutes of a marine mammal being detected within the mitigation zone.

7. If a marine mammal is observed, or acoustically detected, within the mitigation zone, it should be monitored and tracked until it moves out of range. The MMOs should notify the relevant chain of command of the detection and advise that the operation should be delayed. If the marine mammal is not detected again within 20 minutes, it can be assumed that it has left the area, and the works may commence.

8. If an MMO is uncertain whether marine mammals are present within the mitigation zone, they should advise that the activity should be delayed as a precaution until they are certain that no animals are present.

9. A soft-start will be employed for drilling, with the gradual ramping up of works (where possible). The soft-start duration will be a period of not less than 20 minutes. This will allow any marine mammals to move away from the noise source.

10. If a marine mammal enters the mitigation zone during the soft-start, then, whenever possible, the works will cease until the marine mammal exits the mitigation zone and there is no further detection for 20 minutes.

### 5.4.1 Reporting

As per the JNCC guidance, reports detailing the drilling and blasting activity and marine mammal mitigation (the MMO reports) will be sent to the Marine Directorate at the conclusion of the survey. Reports will include:

- Completed MMRFs;
- Date and location of the works;
- A record of all occasions when drilling and blasting occurred, including details of the duration of the pre-works search and soft-start (for drilling) procedures, and any occasions when works activity was delayed or stopped due to the presence of marine mammals;
- Details of watches made for marine mammals, including details of any sightings, and details of the activity (proposed works) during the watches;
- Details of any problems encountered during the drilling or blasting, including instances of non-compliance with the agreed protocols; and
- Any recommendations for the amendment of the protocols.

## 5.5 Acoustic Deterrent Device Protocol

JNCC states that using devices which have the potential to exclude animals from the mitigation zone should be considered. However, ADDs should only be implemented in conjunction with visual and/or acoustic monitoring (PAM) and for as short a period as necessary to minimise the introduction of additional noise.

The following protocol has been designed for use when ADD is considered necessary:

- ADDs should be positioned in the water in close proximity to the explosive source installed.

- MMOs should ensure marine mammals are not present within 1000m range of the ADD ahead of switching on, to avoid PTS (this can be done with the assistance of PAM and MMO pre-works searches).
- If a marine mammal is identified prior to ADD being switched on, ensuring that the animal is given appropriate time to leave the 1km mitigation zone is required (again, this can be supported by PAM and MMO searches). If the marine mammal is not detected again within 20 minutes, it can be assumed that it has left the area and ADD use may commence.
- ADDs should be switched on for a pre-determined number of emissions during the pre-works search and turned off immediately once the works/ detonations have commenced (ADDs should be utilised proportionately).
- The MMO should maintain a post-works search within the mitigation zone for at least 15 minutes after the works have commenced/ last detonation, to look for any evidence of injury to marine life, including fish kills. Any unusual observations should be noted in the report.
- Clear communication channels should exist between MMO(s) / PAM operators and personnel undertaking works/ detonating the explosives. It is recommended that communication channels should be established and in place before the activity commences, with these matters discussed and agreed at a pre-mobilisation meeting.

Based on JNCC Report 615. Acoustic Deterrent Device Selection Database (last updated February 2025), a range of ADDs are available for marine mammals and should be considered, depending on the project. The following ADDs offer ranges out to >1000m for marine mammals and include:

- Aquatec Group Aquamark 848 (>1000m for LF, HF and VHF cetaceans and pinnipeds)
- Terecos Ltd DSMS-4 – Programme 1 (Sequence 1) (>1000m for LF, HF and VHF cetaceans and pinnipeds)Terecos Ltd DSMS-4 – Programme 2 (>1000m for LF, HF and VHF cetaceans and pinnipeds)Terecos Ltd DSMS-4 – Programme 2 (Sequence 2) (>1000m for LF, HF and VHF cetaceans and pinnipeds)

## 5.6 Vessel Movement Mitigation Protocol

The Lerwick Port Authority implements speed restrictions on vessels within Shetland waters. Vessel captains should adhere to agreed routes, speed limits, and consideration of the Scottish Marine Wildlife Watching Code[67] should be in place ahead of construction works commencing (inclusive of dredging)[68].

Training courses such as those provided by the WiSe scheme[69] could be offered to vessel operators.

## 5.7 Additional Good Practice Recommendations

If any dead cetacean is anecdotally observed during construction or operation, it should be reported to the Scottish Marine Animal Stranding Scheme (SMASS) (www.strandings.org), and live marine mammal strandings will be reported to British Divers Marine Live Rescue (www.bdmlr.org.uk).

The MMOs should keep a record of all marine mammal sightings, whether in the mitigation zone or not, to be issued to NatureScot. An understanding of the location of species is essential to appropriately assess the impacts of a proposed development and plan and target effective mitigation, therefore, this data could be used to inform future projects. Biodiversity data are extremely important

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[67] https://www.nature.scot/doc/scottish-marine-wildlife-watching-code-smwwc

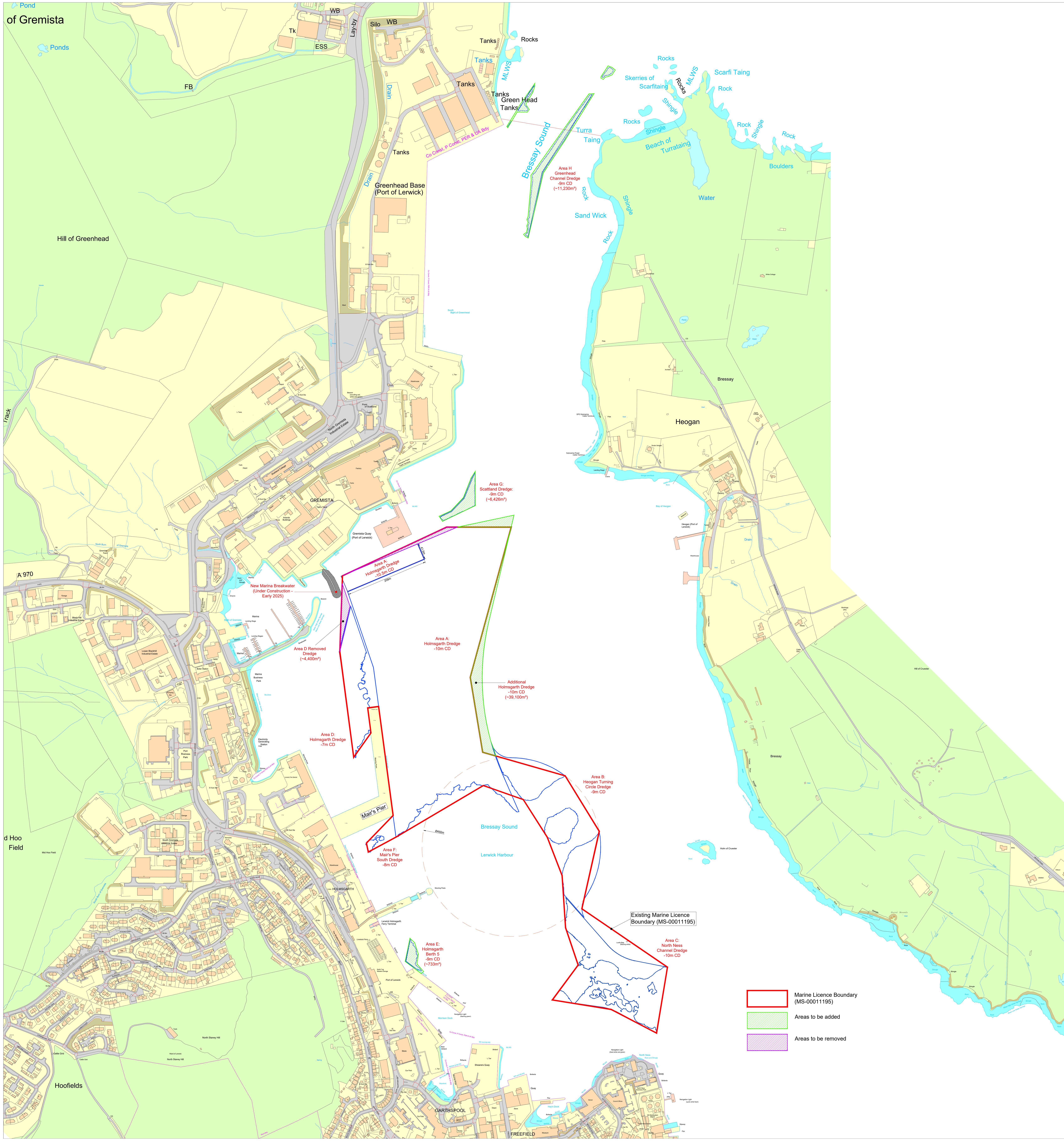
[68] Identified in a project team meeting that 4 knots isn't a safe/practical speed for dredging vessels, and isn't considered necessary as vessels will be using established shipping routes to reach the licensed sea deposit site.

[69] Information available at: https://www.wisescheme.org/ (Accessed October 2025)

as, aside from use in planning and decision making, they are key to delivering state of environment reporting, education, modelling trends in species and habitat distribution, and research and policy making.

# APPENDICES

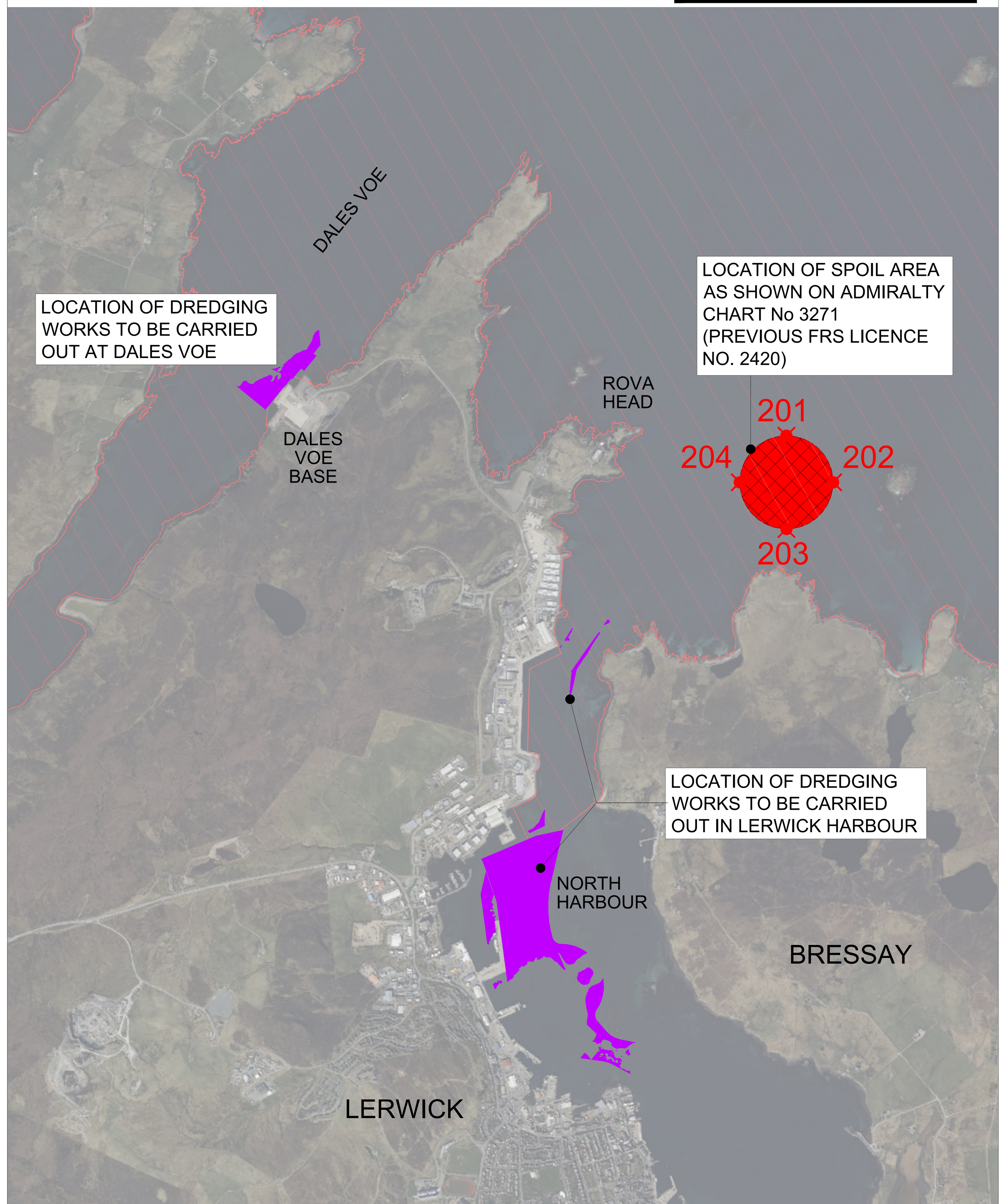
# A SITE LOCATION AND DREDGE DISPOSAL SITE




| | |
|---|---|
| (red outline) | Marine Licence Boundary (MS-00011195) |
| (green hatch) | Areas to be added |
| (pink hatch) | Areas to be removed |

DENOTES SPECIAL PROTECTION AREA (SPA)






## LOCATION PLAN

Scale 1: 20,000

0 750 1500 Metres

# NORTH HARBOUR DREDGING WORKS LAYOUT OF AMENDMENTS

Scale 1: 5,000

0 200 400 Metres

| REV | DATE | REVISION | | |
|---|---|---|---|---|
| - | 02.07.205 | Amendments to Marine Licence (MS-00011195) | [ R | [R |
| REV | DATE | REVISION | [Re | [Re |



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Aberdeen; Dundee; Glasgow; Lerwick; Inverness; Thurso; Stromness; Southampton; Falkland Islands

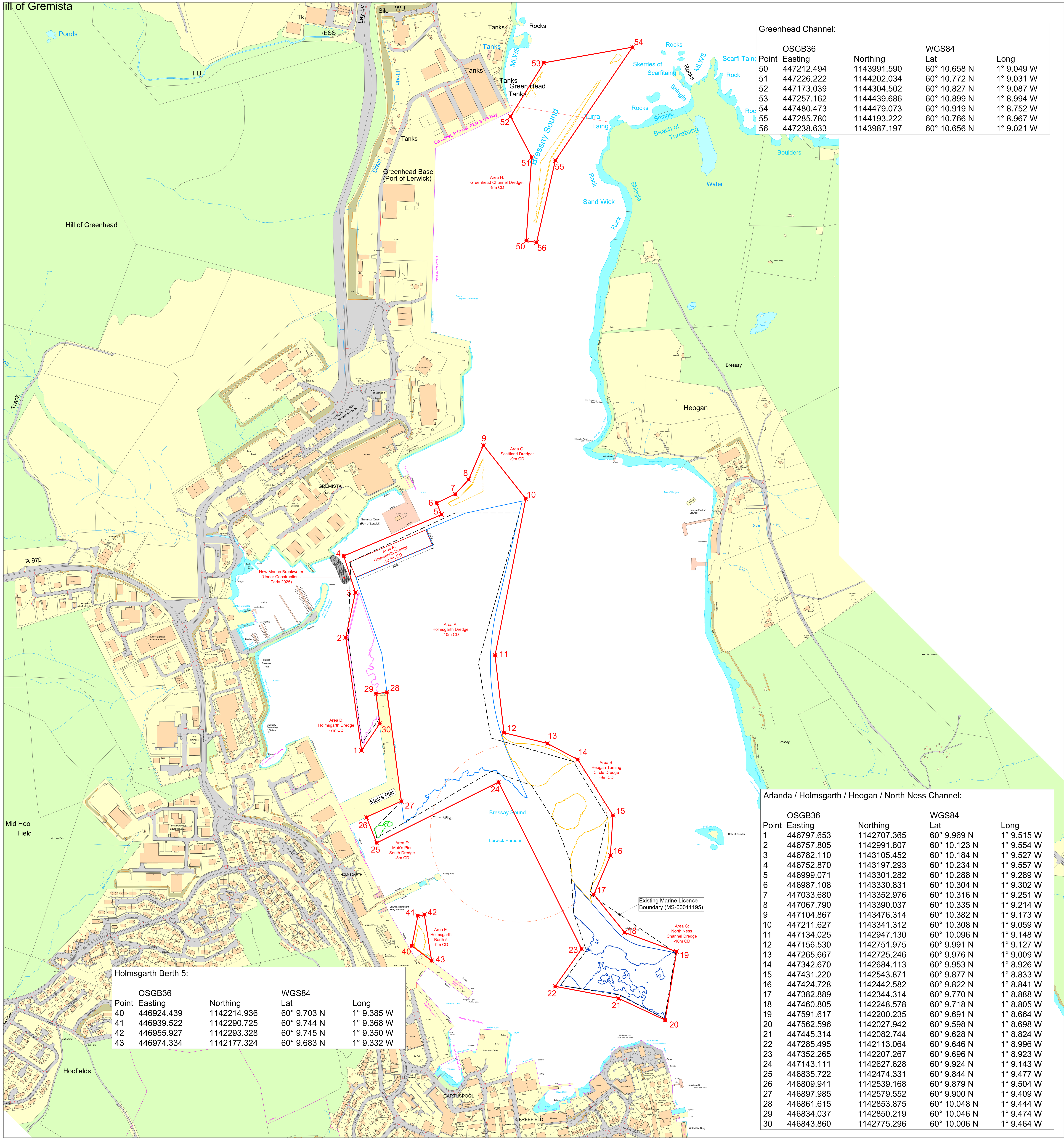
PROJECT :
Lerwick Port Authority
Lerwick Harbour Dredging

TITLE :
Marine Consents
North Harbour Amendments (MS00011195)

| DRAWN : | DATE : | CHECKED : | APPROVED : |
|---|---|---|---|
| [Red | June 2025 | [Re | [Re |

| SCALE : (A1) | DRAWING STATUS : |
|---|---|
| 1:2,500 | Consents |

| DRAWING No : | REV : |
|---|---|
| 232029-MD-20 | - |




Greenhead Channel:

| Point | OSGB36 Easting | Northing | WGS84 Lat | Long |
|---|---|---|---|---|
| 50 | 447212.494 | 1143991.590 | 60° 10.658 N | 1° 9.049 W |
| 51 | 447226.222 | 1144202.034 | 60° 10.772 N | 1° 9.031 W |
| 52 | 447173.039 | 1144304.502 | 60° 10.827 N | 1° 9.087 W |
| 53 | 447257.162 | 1144439.686 | 60° 10.899 N | 1° 8.994 W |
| 54 | 447480.473 | 1144479.073 | 60° 10.919 N | 1° 8.752 W |
| 55 | 447285.780 | 1144193.222 | 60° 10.766 N | 1° 8.967 W |
| 56 | 447238.633 | 1143987.197 | 60° 10.656 N | 1° 9.021 W |

Holmsgarth Berth 5:

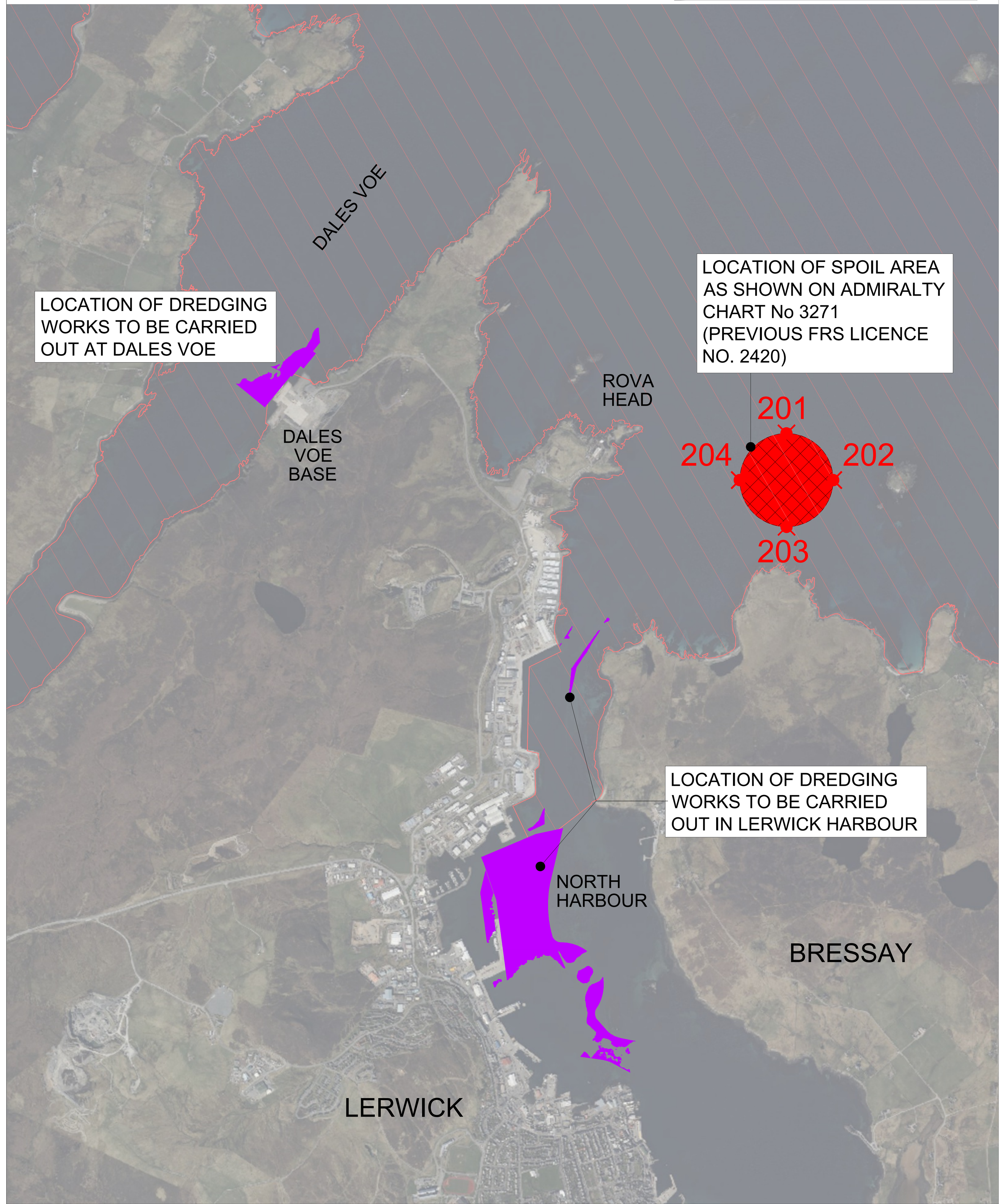
| Point | OSGB36 Easting | Northing | WGS84 Lat | Long |
|---|---|---|---|---|
| 40 | 446924.439 | 1142214.936 | 60° 9.703 N | 1° 9.385 W |
| 41 | 446939.522 | 1142290.725 | 60° 9.744 N | 1° 9.368 W |
| 42 | 446955.927 | 1142293.328 | 60° 9.745 N | 1° 9.350 W |
| 43 | 446974.334 | 1142177.324 | 60° 9.683 N | 1° 9.332 W |

Arlanda / Holmsgarth / Heogan / North Ness Channel:

| Point | OSGB36 Easting | Northing | WGS84 Lat | Long |
|---|---|---|---|---|
| 1 | 446797.653 | 1142707.365 | 60° 9.969 N | 1° 9.515 W |
| 2 | 446757.805 | 1142991.807 | 60° 10.123 N | 1° 9.554 W |
| 3 | 446782.110 | 1143105.452 | 60° 10.184 N | 1° 9.527 W |
| 4 | 446752.870 | 1143197.293 | 60° 10.234 N | 1° 9.557 W |
| 5 | 446999.071 | 1143301.282 | 60° 10.288 N | 1° 9.289 W |
| 6 | 446987.108 | 1143330.831 | 60° 10.304 N | 1° 9.302 W |
| 7 | 447033.680 | 1143352.976 | 60° 10.316 N | 1° 9.251 W |
| 8 | 447067.790 | 1143390.037 | 60° 10.335 N | 1° 9.214 W |
| 9 | 447104.867 | 1143476.314 | 60° 10.382 N | 1° 9.173 W |
| 10 | 447211.627 | 1143341.312 | 60° 10.308 N | 1° 9.059 W |
| 11 | 447134.025 | 1142947.130 | 60° 10.096 N | 1° 9.148 W |
| 12 | 447156.530 | 1142751.975 | 60° 9.991 N | 1° 9.127 W |
| 13 | 447265.667 | 1142725.246 | 60° 9.976 N | 1° 9.009 W |
| 14 | 447342.670 | 1142684.113 | 60° 9.953 N | 1° 8.926 W |
| 15 | 447431.220 | 1142543.871 | 60° 9.877 N | 1° 8.833 W |
| 16 | 447424.728 | 1142442.582 | 60° 9.822 N | 1° 8.841 W |
| 17 | 447382.889 | 1142344.314 | 60° 9.770 N | 1° 8.888 W |
| 18 | 447460.805 | 1142248.578 | 60° 9.718 N | 1° 8.805 W |
| 19 | 447591.617 | 1142200.235 | 60° 9.691 N | 1° 8.664 W |
| 20 | 447562.596 | 1142027.942 | 60° 9.598 N | 1° 8.698 W |
| 21 | 447445.314 | 1142082.744 | 60° 9.628 N | 1° 8.824 W |
| 22 | 447285.495 | 1142113.064 | 60° 9.646 N | 1° 8.996 W |
| 23 | 447352.265 | 1142207.267 | 60° 9.696 N | 1° 8.923 W |
| 24 | 447143.111 | 1142627.628 | 60° 9.924 N | 1° 9.143 W |
| 25 | 446835.722 | 1142474.331 | 60° 9.844 N | 1° 9.477 W |
| 26 | 446809.941 | 1142539.168 | 60° 9.879 N | 1° 9.504 W |
| 27 | 446897.985 | 1142579.552 | 60° 9.900 N | 1° 9.409 W |
| 28 | 446861.615 | 1142853.875 | 60° 10.048 N | 1° 9.444 W |
| 29 | 446834.037 | 1142850.219 | 60° 10.046 N | 1° 9.474 W |
| 30 | 446843.860 | 1142775.296 | 60° 10.006 N | 1° 9.464 W |

DENOTES SPECIAL PROTECTION AREA (SPA)






## LOCATION PLAN

Scale 1: 20,000

0 750 1500 Metres

## NORTH HARBOUR DREDGING WORKS COORDINATES

Scale 1: 5,000

0 200 400 Metres

| REV | DATE | REVISION | | |
|---|---|---|---|---|
| A | 10.07.2025 | Minor Amendments to Licence Coordinates | [R | [R |
| - | 02.07.2025 | Amendments to Marine Licence (MS-00011195) | [R | [R |
| REV | DATE | REVISION | [Re | [Re |



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PROJECT :
Lerwick Port Authority
Lerwick Harbour Dredging

TITLE :
Marine Consents - Amendments to MS-00011195
North Harbour Coordinates

| DRAWN : | DATE : | CHECKED : | APPROVED : |
|---|---|---|---|
| [Red | June 2025 | [Re | [Re |

| SCALE : (A1) | DRAWING STATUS : |
|---|---|
| 1:2,500 | Consents |

DRAWING No : 232029-MD-21 REV : A

# B SUBACOUSTECH REPORT

[Redacted]

**Arch Henderson**

Stewart Building,

Lerwick,

Shetland,

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11th December 2025

**Re: Lerwick Port Authority – Lerwick Harbour & Dales Voe Dredging. Underwater noise generated by drill and blast operations. *Subacoustech Report Ref. P438LR0103***

Please note that this report issue is a revision to Subacoustech's previous report ref. P438LR0101, to include results for harbour porpoise. Additions to the text are highlighted in blue.

Additional revisions are included in this report issue, updating the previous P438LR0102 regarding whales, dolphins, and the inclusion of NOAA Level B impulsive thresholds for disturbance, with additions highlighted in green.

**Introduction and basic environmental underwater noise concepts**

Works under Marine Licences MS-00011195 and MS-00011213 for dredging Lerwick Harbour and Dales Voe with the Magnor back-hoe dredger are now complete. Although the dredger was able to extract much of the substrate at each site, there is some hard rock that it is unable to remove, and for this, blasting is proposed to loosen the rock to enable its removal. This is currently proposed over five weeks at Lerwick Harbour and 2.5 weeks at Dales Voe. The use of the explosives in drilled boreholes will necessarily generate underwater noise, which has the potential to adversely affect marine species in the vicinity.

It is well understood that there is limited data publicly (and privately) available for the underwater noise caused by borehole blasting, making a confident assessment of this noise and its effect on the environment challenging. This letter report will consider the most suitable underwater noise data available to Subacoustech Environmental to provide the best estimate for the potential impacts in the two locations. During initial test blasting activities, underwater noise monitoring will be undertaken which will confirm the amount of noise generated at each site and contribute to the overall knowledge base.

The following letter report will primarily consider the situation at Dales Voe and Lerwick Harbour in the context of recent measurements Subacoustech took of drill and blast activities at Singapore Harbour in 2024, also undertaken for the removal of hard rock sections of a waterway during channel deepening works. Results from this exercise will also be compared with predictions using Soloway and Dahl (2014)[1].

[1] Soloway, A. G., & Dahl, P. H. (2014). Peak sound pressure and sound exposure level from underwater explosions in shallow water. The Journal of the Acoustical Society of America, 136(3), EL219-EL223. http://dx.doi.org/ 10.1121/1.4892668

The following basic concepts should be understood. Borehole blasting for the clearance of rock 'overburden' (the top layer of rock in a sea or riverbed) requires a grid of boreholes of various lengths and diameters to be drilled, into which are placed an explosive 'pack' which are detonated in sequence, with a delay of a few milliseconds between each. The amount of explosive in each hole will have a 'charge weight' in kilograms, each is likely to be different, but from a noise perspective, this leads to a serious of individual 'peaks' of noise in the blast sequence. The greatest individual noise 'peak' will tend to be associated with the largest charge, known as the Maximum Instantaneous Charge, or MIC. The total charge weight detonated in a sequence will contribute to an overall noise exposure. Both of these elements are relevant in the assessment of noise impact.

It is estimated that the MIC required at Dales Voe will be no more than 110 kg in any location, with an average of 34-64 kg; at Lerwick Harbour, the estimated MIC is up to 130 kg, with an average of 33-60 kg. An indicative upper total charge weight in all holes in a sequence is suggested to be around 700 kg, based on an upper extent of the estimated 400 kg-1250 kg over two sequences provided in the "Trial Blast – Proposed Underwater Acoustic Monitoring Method Statement" (Arch Henderson doc. No. 232029-MD-LOT-D&B).

All species have different hearing capabilities and sensitivities, but although the greatest concern in both locations is potential for harm to the harbour seal, the following assessment will consider all marine mammal species categories. Harbour porpoise are noted as being the most sensitive species to noise, and there is a small risk that individuals could be present, although it is noted in the Marine Mammal Risk Assessment (Envirocentre doc. no. 15428) that between 2023 and 2025 the nearest animals were sighted approximately 14 km from the Dales Voe site. No individuals were seen in the proposed development site. In order to mitigate the risk, Marine Mammal Observers will be used to ensure no marine mammals are present within 1 km of the blast location. The assessment will be made such that there should be no risk of Permanent Threshold Shift (PTS)[2], or damage to the hearing ability of a seal, outside of this 1 km range. There must be consideration of the maximum instantaneous (peak sound pressure level, $SPL_{peak}$[3]) noise level, controlled by the MIC, and the total noise exposure (sound exposure level, SEL[4]), controlled by the total charge weight detonated in the sequence. Guidance considers these 'dual criteria' where both are relevant, and the 'impact range' should be whichever represents the worst case.

## Predictions using Soloway and Dahl (2014)

Soloway and Dahl (2014) sets out calculations for the prediction of noise from detonations of explosives underwater, with a specific focus on UXO (i.e. unconstrained detonation in the water column). MTD 96/101 also states that the explosive peak pressure of explosions in rock reduces to approximately 5% of the value for freely suspended charges, or 30% for total exposure. Following the prediction in Soloway and Dahl (2014), which itself follows Arons (1954)[5], and including the correction for explosives in rock noted in MTD 96/101, predicts a noise level of 191.6 dB $SPL_{peak}$ at 1000 m from a blast with MIC of 130 kg, which is substantially below the threshold of instantaneous PTS onset for seals of 223 dB $SPL_{peak}$. It is also well below the 202 dB

---

[2] Note that in NMFS (2024), PTS is considered under the wider category of Auditory Injury.
[3] $SPL_{peak}$ metric is commonly referred to using $L_{P,pk}$ in contemporary underwater noise reporting but $SPL_{peak}$ has been used in the document for the purposes of familiarity with readers.
[4] SEL metric is commonly referred to using $L_{E,p}$ in contemporary underwater noise reporting, but SEL has been used in this report for the purposes of familiarity with readers.
[5] Arons A. B. (1954). Underwater explosion shock wave parameters at large distances from the charge. J. Acoust. Soc. Am. 26, 343–346

SPL$_{peak}$ threshold for harbour porpoise, as per NMFS (2024)[6]. The estimated distance at which 223 dB SPL$_{peak}$ (harbour seal) is predicted to occur is approximately 45 m from the blast location using this methodology; 202 dB (harbour porpoise, VHF weighted as per Southall *et al.,* 2019[7]) would occur at 350 m. The total charge weight of 700 kg (including the 30% correction for embedded charges) leads to a noise level of 183 dB SEL (PCW weighted, as per Southall *et al*., 2019[7]) at 1000 m, marginally below the 185 dB SEL limit for PTS onset in seals[8]. For harbour porpoise, the total charge weight (with the correction) leads to a noise level of 165 dB SEL at 1000 m, which is somewhat in excess of the 155 dB SEL PTS threshold for this species (155 dB SEL is estimated at 2.4 km).

Note that calculations are based on a charge weight of TNT and charge weights of relevant explosive should be converted using TNTeq (TNT equivalent). Based on Simoens *et al.* (2011)[9], the emulsion explosives proposed at the Shetlands sites (and also used in Singapore, below), have a TNTeq conversion factor of 1 for peak pressure and 0.7 for exposure. For reasons of precaution (and simplicity) a TNTeq with a 1:1 ratio has been used in the calculations.

**Comparison with measurements at Singapore Harbour, 2024**

The most recent and comprehensive dataset for underwater noise measurements taken during drill and blast operations was taken in June 2024 in Singapore Harbour[10] by Subacoustech, where nine charge sequences were sampled successfully. The charges measured at the Singapore Harbour site are similar to those proposed here (although at some locations the MIC could be higher in Shetland sites). This location had a similar depth to the Shetland sites, up to 20 m, although much of the Shetland sites are shallower, which is beneficial for restricting sound transmission with distance.

The MICs deployed for the project in Singapore were smaller than those proposed at the Shetland sites, with a highest value of 50 kg compared to 110 kg to 130 kg, although 50 kg is representative of a typical MIC charge weight rather than the absolute maximum.

The results shown in Figure 1 and Figure 2 were obtained from the measurements at Singapore Harbour. A range of distances were sampled, between 580 m and 2000 m (most at 800 m to 1000 m), and the measurements were normalised using a simple acoustic principle (15.log[r]), as if all measurements were sampled at 1000 m and the only variable was the charge weight.

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[6] National Marine Fisheries Service (NMFS) (2024). *2024 update to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 3.0): Underwater and in-air criteria for onset of auditory injury and temporary threshold shifts.* U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-71.
[7] Southall B L, Finneran J J, Reichmuth C, Nachtigall P E, Ketten D R, Bowles A E, Ellison W T, Nowacek D P, Tyack P L (2019). *Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects.* Aquatic Mammals 2019, 45 (20, 125-232) DOI 10.1578/AM.45.2.2019.125.
[8] Note that criteria for PTS onset based on the instantaneous SPL$_{peak}$ threshold use the NMFS (2024) guidance, whereas the SEL criteria use the older Southall *et al.* (2019) guidance. This is because the SPL$_{peak}$ thresholds are straightforward to update, whereas the species-weighted SEL thresholds would require considerable reanalysis of the Singapore data to update and enable a direct comparison. Subacoustech's analysis previously of the difference between seal criteria in Southall *et al.* (2019) and NMFS (2024) indicate that the overall difference between the two criteria is relatively small.
[9] Simoens B, Lefebvre M H, Minami F (2011) *Influence of Different Parameters on the TNT-Equivalent of an Explosion.* Central European Journal of Energetic Materials, 2011, 8(1), 53-67
[10] Mason T and Morgan I (2024) *Underwater noise monitoring, drilling and blasting in Temasek Fairway, Singapore*. Subacoustech report ref. P398R0102

This analysis suggests that all charges sampled at Singapore Harbour were lower than the instantaneous PTS onset threshold, although noting again that the MIC for the Singapore campaign was limited to 50 kg and the trend is indicative of an increase above the instantaneous limit at higher MICs.

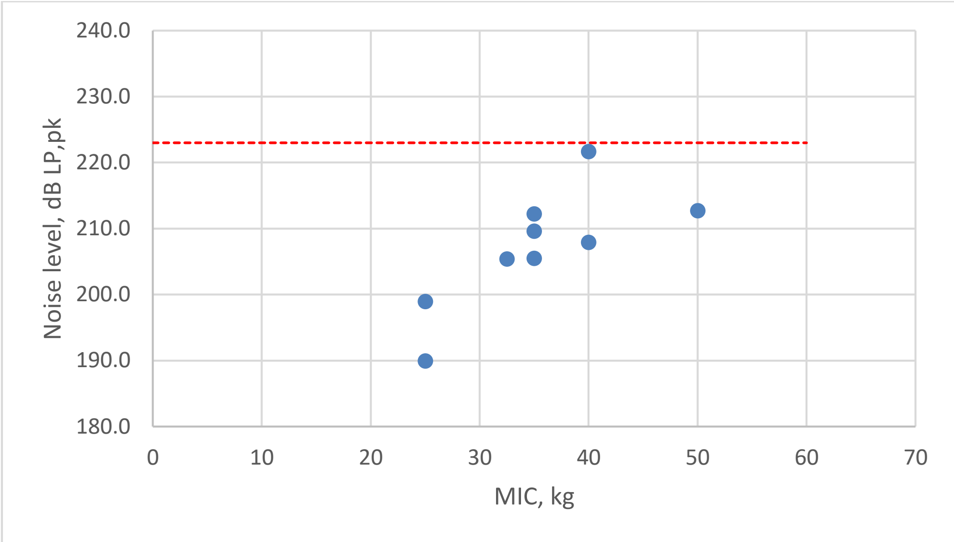


*Figure 1 – $SPL_{peak}$ measurements against MIC size, normalised to 1000 m, with seal instantaneous PTS threshold marked (223 dB $SPL_{peak}$, as per NMFS, 2024 threshold).*

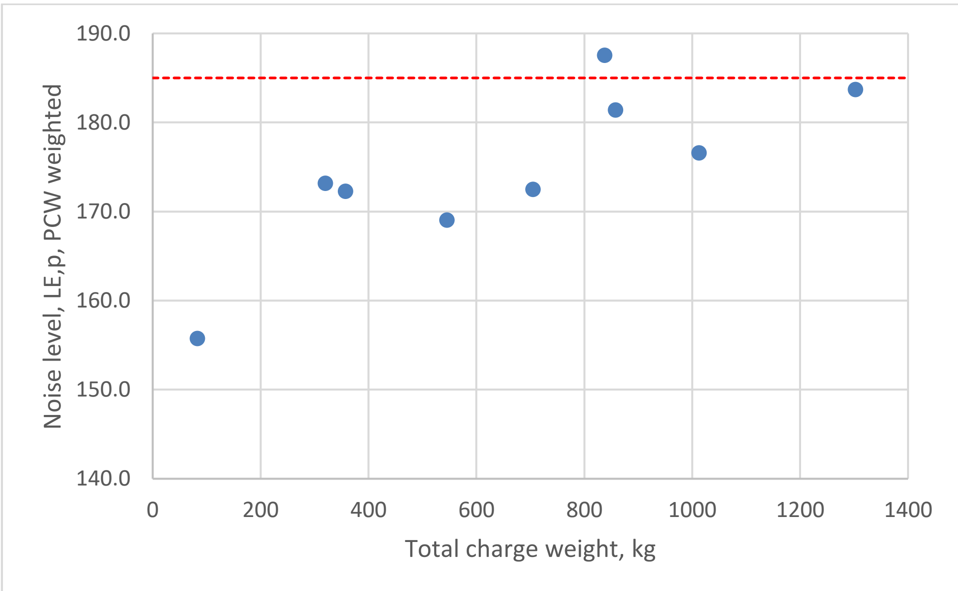


*Figure 2 – SEL measurements against total charge weight, normalised to 1000 m, with seal PTS exposure threshold marked (185 dB SEL, as per Southall et al., 2019 threshold).*

Here, the 700 kg estimated total charge weight in a detonation sequence is within the boundaries of the measurements sampled and is expected to be likely just below the PTS onset threshold. However, due to the variability of the measurements, indeed explosive measurements generally, there is still a risk of exceedance at the highest total combined charge weights.

The equivalent charts have been extracted for harbour porpoise, again showing the measurements of blast noise normalised to 1000 m using the $SPL_{peak}$ and SEL metrics.

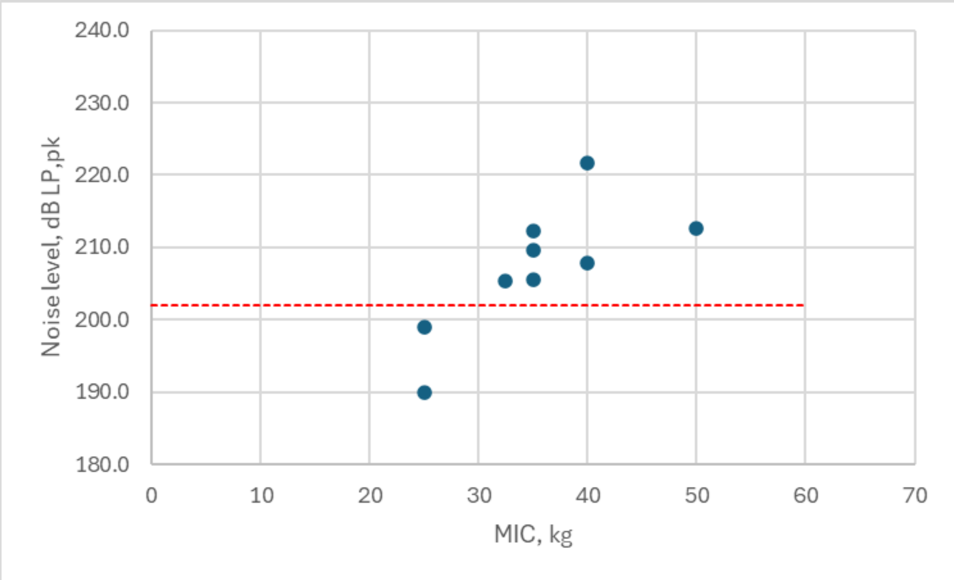


*Figure 3 – $SPL_{peak}$ measurements against MIC size, normalised to 1000 m, with harbour porpoise instantaneous PTS threshold marked (2 dB $SPL_{peak}$, as per NMFS, 2024 threshold).*

It is clear here that at an MIC in excess of approximately 30 kg, the measurements exceed the harbour porpoise $SPL_{peak}$ PTS threshold (202 dB $SPL_{peak}$) at 1000 m. Thresholds for all other species hearing groups are 222 dB $SPL_{peak}$ or greater[11], and so are not exceeded.

[11] Summary of NMFS, 2024 auditory injury $SPL_{peak}$ thresholds: 222 dB (LF cetacean, e.g. minke whale), 230 dB (HF cetacean, e.g. Risso's dolphin), 202 dB (VHF cetacean, e.g. harbour porpoise), 223 dB (PCW, pinnipeds in water, e.g. harbour seal)

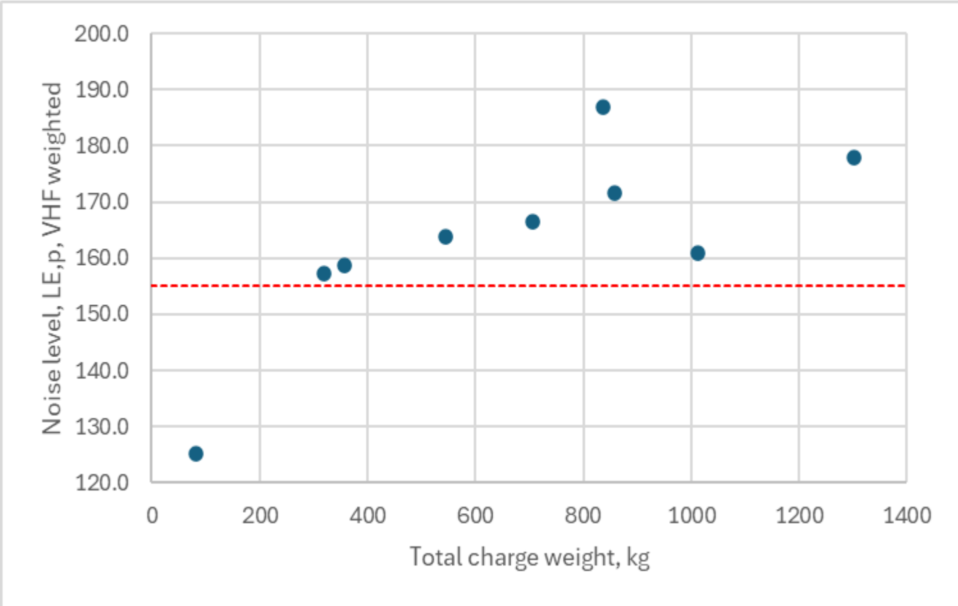


*Figure 4 – SEL measurements against total charge weight, normalised to 1000 m, with harbour porpoise PTS exposure threshold marked (155 dB SEL, as per Southall et al., 2019 threshold).*

Again here we can see that using the total charge weights measured, most larger explosive quantities exceed the Southall *et al.* (2019) harbour porpoise SEL threshold at 1000 m.

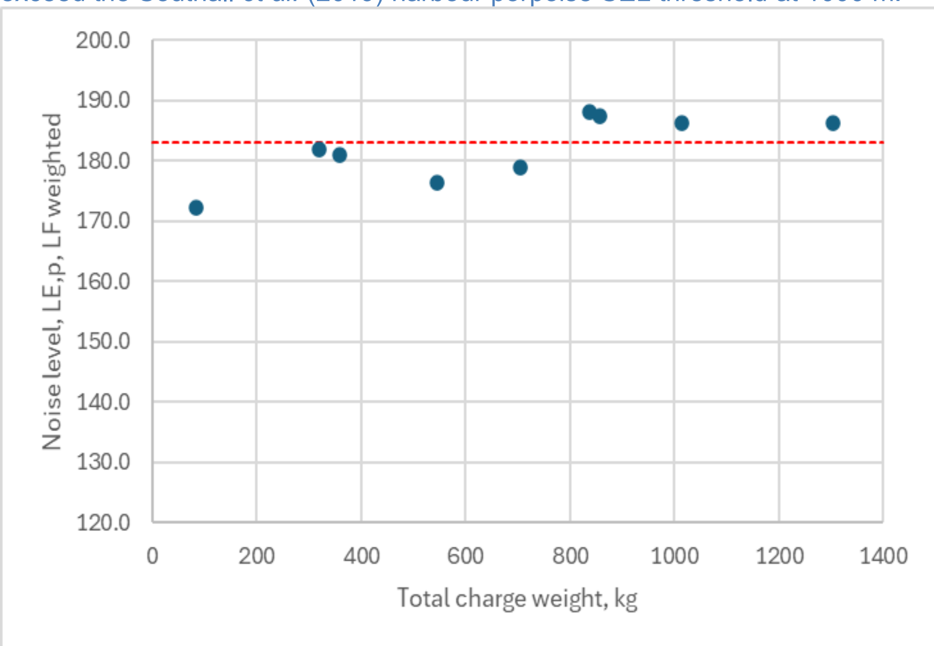


*Figure 5 – SEL measurements against total charge weight, normalised to 1000 m, with low frequency cetacean (i.e. minke whale) PTS exposure threshold marked (183 dB SEL, as per Southall et al., 2019 threshold).*

All detonations at or below 700 kg total charge weight were less than the criterion.

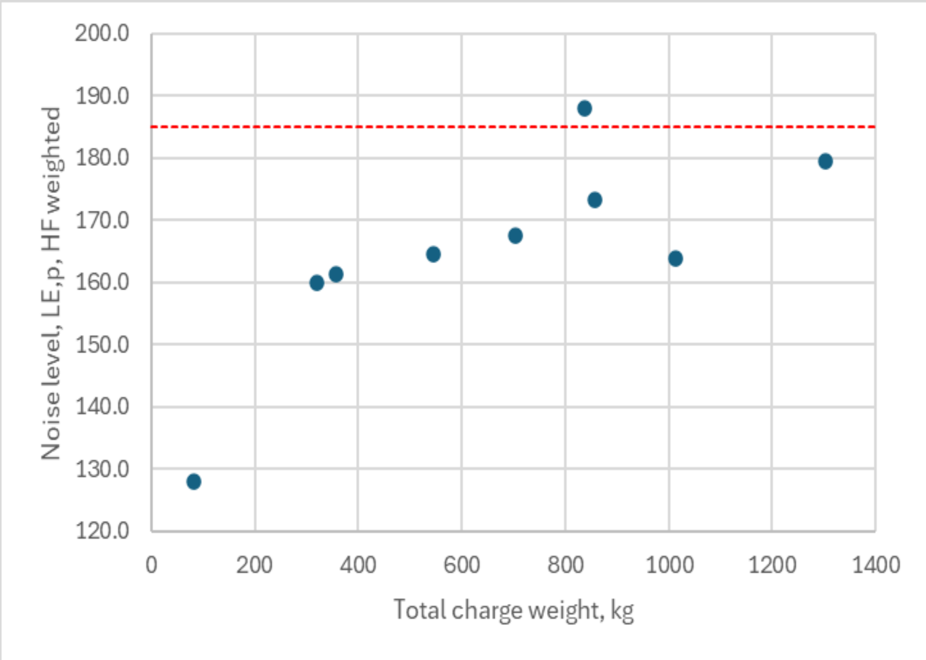


*Figure 6 – SEL measurements against total charge weight, normalised to 1000 m, with high frequency cetacean (i.e. Risso's dolphin) PTS exposure threshold marked (183 dB SEL, as per Southall et al., 2019 threshold).*

The measured noise levels at or normalised to 1000 m for all detonations (aside from one outlier) were below the PTS noise criterion.

### Estimation of disturbance

The National Marine Fisheries Service (NMFS) in the United States has used a concept of Level B Harassment to identify a noise level at which disturbance could occur in marine mammals. For impulsive noises this is often quoted as 160 dB $SPL_{rms}$ but crucially this threshold is not intended for explosive noise. However, in their Summary of Acoustic Thresholds (2025)[12], NMFS provides a series of weighted SEL behavioural thresholds for explosions considering multiple detonations for relevant species groups. These thresholds are provided alongside the calculated result for a selection of charge weights (with embedded charge correction).

*Table 1 – Behavioural thresholds for underwater explosives, NMFS (2025) and predicted impact ranges. Note these use the NMFS (2024)[6] marine mammal weightings and linked thresholds, dB re 1 µPa²s*

| Hearing Group | Example species | Threshold, weighted | 20 kg | 30 kg | 50 kg | 700 kg |
|---|---|---|---|---|---|---|
| LF Cetaceans | Minke whale | 163 dB SEL | 20 km | 24 km | 30 km | 93 km |
| HF Cetaceans | Risso's dolphin | 173 dB SEL | 110 m | 140 m | 170 m | 520 m |
| VHF Cetaceans | Porpoise | 139 dB SEL | 3.4 km | 3.6 km | 3.9 km | 5.4 km |
| Phocid pinnipeds | Seal | 163 dB SEL | 4.2 km | 5.1 km | 6.5 km | 20 km |

[12] https://www.fisheries.noaa.gov/s3/2025-09/MM-Acoustic-Thresholds-508-secure-SEPT-2025-OPR1.pdf


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The long-range results calculated for LF cetaceans is likely to be a significant over-estimation of the real risk, due to the relatively shallow water at the sites which will likely attenuate the noise more quickly than the calculation assumes. It is worth also being mindful of the context: a widespread clearance of an area would be much more likely where high noise levels are present for an extended period. For a single detonation (effectively also a single collection of detonations) lasting less than a second, with many hours between the explosive events, it is hard to localise the sound and so this is thought most likely to lead to a startle reaction in individuals rather than causing a displacement of marine mammals.

**Discussion**

There is clearly a divergence in the theoretical and empirical results. While the theoretical calculations for the instantaneous $SPL_{peak}$ indicate that there is significant headroom before reaching the seal PTS onset threshold at 1 km, they are very close to (but still beneath) the threshold based on SEL exposure. Despite this, the measurements in Singapore Harbour indicate a risk of exceedance at the maximum MIC proposed at the Shetland sites for the instantaneous PTS $SPL_{peak}$ thresholds at 1 km. Using the total exposure (rather than instantaneous) threshold, the predicted noise appears to be just beneath the threshold, in line with the theory. Considering harbour porpoise however, their greater sensitivity to noise shows that at the larger MICs and total exposures, their PTS thresholds would be exceeded at 1 km using both theoretical and empirical measures for all except theoretical instantaneous calculation.

In some ways divergence between theoretical and empirical measures is not surprising; every detonation is different. This is especially true where the explosives are drilled into rock, and the depth and structure of the particular rock type will affect the noise ultimately transmitted into the water. However on the basis of the measurements available, no exceedance was found at 1 km for MICs up to 50 kg for seals, although an exceedance for harbour porpoise is more likely. All other species group had a lower sensitivity and a lower risk of PTS. In terms of noise transmission over 1 km, the slightly shallower depths around the Lerwick sites are likely to lead to slightly lower noise levels, although its real effect is more complicated to predict and beyond the scope of this report. There is a potential for behavioural disturbance in seals of 6.5 km with a charge weight of 50 kg or up to 20 km for a total charge weight of 700 kg, but due to the single event nature of explosive detonations, it is thought likely that this would lead to a short-term startle reaction rather than individuals leaving the area.

It should be borne in mind that the instantaneous $SPL_{peak}$ PTS calculations use the maximum MIC proposed at the Shetland sites, and so the risk from the majority of the detonations is anticipated to be lower for most of the sites and times. The real risk to harbour porpoise should not be overestimated either, due to the small population in the area and the low likelihood of an individual being present near to the blast sites, especially due to the elevated noise levels from drilling prior to blasting.

It is understood that a major part of the mitigation proposed for the drill and blast works at the sites will be the use of marine mammal observers and underwater noise monitoring at the sites. Measurements will start with lower MICs and incrementally increase until or in case there is a clear exceedance of the impact thresholds. It is suggested that, as the worst case theoretical calculations and empirical measurements indicate that the seal PTS is expected to remain below the threshold for SEL (total charge weights), then there is some comfort that available data show that the threshold using this metric is unlikely to be exceeded at the Shetland sites. However, there remains greater uncertainty based on the $SPL_{peak}$ thresholds, and the ultimate impact is likely to be dependent on the specific conditions at the Shetland sites; indeed a comparison between the noise levels produced at the two sites and the existing data will be useful. The underwater noise monitoring exercise will be important to confirm the particular characteristics from blasting at various charge weights at the two sites and provide confidence in the underwater noise levels in comparison with the theoretical data and those acquired at a different location.

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